524 SER. II, VOL. 16 *April, 1954* NO. 6

TRANSACTIONS
OF
THE NEW YORK ACADEMY OF SCIENCES

Editor

ROY WALDO MINER

Contents

Terrestrial and Submarine Unconsolidated Deposits in the Vicinity of Eastport, Maine. *By* JOSEPH E. UPSON 288

Symposium on Age Determination in Animals:

Some Longevity Records of Vertebrates. *By* ROSS F. NIGRELLI 296

Age Determination in Molluscs. *By* HAROLD H. HASKIN 300

Age Determination of Fish. *By* ALFRED PERLMUTTER 305

Age Determination in Mammals. *By* CHARLES P. GANDAL 312

The Genus *Actinoplanes* and Its Relatives. *By* JOHN N. COUCH 315

Notice to Active Members 319

Conference Held 320

New Members 321

Copyright, 1954, by The New York Academy of Sciences

TRANSACTIONS of The New York Academy of Sciences, Series II, Volume 16, No. 6, April, 1954.

This publication is distributed to members and is published monthly from November to June, inclusive, by The New York Academy of Sciences, 2 East Sixty-third Street, New York 21, New York.

Executive Director

EUNICE THOMAS MINER

UNIVERSITY OF MICHIGAN
GENERAL LIBRARY

SECTION OF GEOLOGY AND MINERALOGY

TERRESTRIAL AND SUBMARINE UNCONSOLIDATED DEPOSITS IN THE VICINITY OF EASTPORT, MAINE*

By JOSEPH E. UPSON**

INTRODUCTION

In 1951 the United States Geological Survey, at the request of the Corps of Engineers, United States Army, made an investigation by sonic and geologic methods of the extent and thickness of unconsolidated deposits beneath the sea in the vicinity of Eastport, Me. The area is at the southern end of Passamaquoddy Bay in Maine, and New Brunswick, Canada, where the average daily tidal range is about 18 feet, and large quantities of water move in and out twice a day (FIGURE 1). The results of the sonic work and preliminary results of the geologic study were released in December 1952 (Smith, Upson, and others). A further description of the sonic work is given by Smith and Nichols (1953).

The topographically irregular area, with many small islands and mainland promontories, is typical of a drowned coastline (see FIGURES 1-3). Smoothly rounded hills, with flanking cliffs locally, rise to maximum altitudes of about 300 feet. There are scattered exposures of bedrock in the higher areas. At lower altitudes the bedrock is covered by unconsolidated sediments, except along most of the shores, where it forms steep cliffs. Beneath the sea channels, the water ranges from 10 to about 400 feet deep.

GEOLOGY

General features. Surficial deposits of Pleistocene and Recent age rest upon deformed consolidated rocks of Silurian and Devonian age. The older rocks are of igneous, metamorphic, and sedimentary origin. They have been mapped and studied by Bastin and Williams (1914), Perry and Alcock (1945), and Alcock (1946). Bastin also described the surficial deposits near Eastport. Perkins (Leavitt and Perkins, 1935) described and mapped some of the surficial deposits, mostly farther south and west.

The surficial deposits are mainly glacial deposits and marine deposits that were formed in Wisconsin and post-Wisconsin time, either in direct association with glacial ice or not long after retreat of the ice. They are the chief concern of this paper. The deposits are divided into six units designated, from older to younger, as follows: till, outwash, marine clay and silt, older shore deposits, and Recent beach deposits and peat.

Glacial and Marine Deposits

Till. The till forms a discontinuous cover on the bedrock surface in most of the area. It is overlain at places by all the other deposits. It is compact, clayey to stony, and gray colored. It is not appreciably weathered, and so presumably is of late Pleistocene age. At most places it is only a few inches to a few feet thick, but on the mainland east of Lubec Neck and along the west shore of Campobello Island about from Cranberry Point to Friar Head some bodies are 20 feet or more thick. One such body of till is banked against a bedrock hill immediately east of Mulholland Point, where it is exposed in the 20-foot bank below the lighthouse.

Outwash. Several bodies of irregularly stratified, locally crossbedded, fairly well sorted sand and gravel were deposited by streams flowing off glacial ice, or in water at the ice edge. These deposits are younger

* This paper, illustrated with lantern slides, was presented at the meeting of the Section on March 1, 1954. Publication is authorized by the Director, U.S. Geological Survey.

** U.S. Geological Survey, Mineola, Long Island, N.Y.

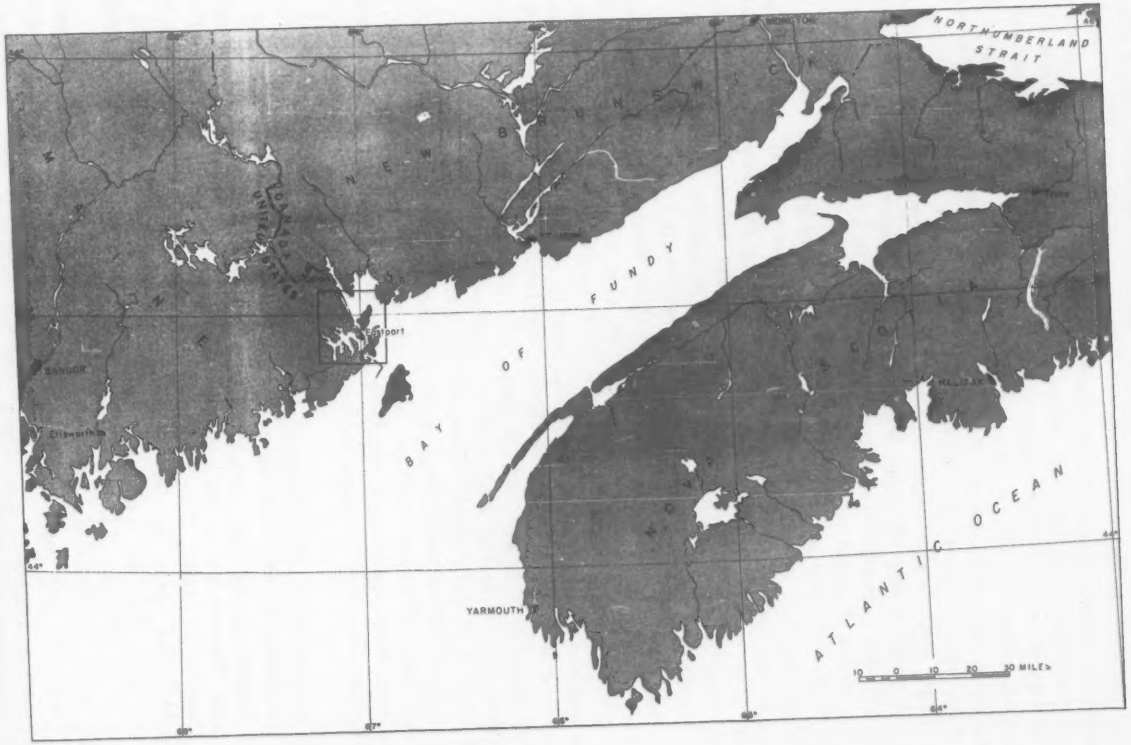

FIGURE 1. Map showing location of the area in the vicinity of Eastport, Maine.

than the till. They occur at altitudes higher than the older shore deposits described in the next paragraph. The most extensive body of outwash underlies and forms an even-surfaced plain across the southern part of Campobello Island. The western edge of this plain is a little higher than the eastern edge and lies at the shore; hence it must have been formed when ice stood immediately adjacent. A smaller body is on Lubec Neck, where exposures in a gravel pit reveal highly contorted beds of outwash intimately associated with compact till. Some bodies of gravel on Moose Island near Eastport have straight, steeply inclined bedding, and may have been deposited adjacent to ice (see page 11, Bastin and Williams, 1914).

Marine Clay and Silt. Overlying the till in low places, and lapping against higher bodies of till and outwash, are extensive deposits of banded clay and silt. As exposed, this material is nearly everywhere massive and blue or dark brownish in color; it is mostly clay but with faint to distinct bands of dark-red or purple silt, or fine sand. The clay is generally stiff, plastic, and cohesive. It occurs in beds a fraction of an inch to six inches thick. Many of the thicker clay beds and massive portions contain scattered small pebbles and, at one or two localities, the clay contains marine shells.

These deposits occur extensively in the vicinity of Cobscook Bay and the south shore of Passamaquoddy Bay, and locally in the Lubec Narrows and at the southern end of Campobello Island. They are not found higher than about 60 feet above present sea level. They are considered the equivalent of marine clays that occur elsewhere in Maine (Goldthwait, 1949) and Canada. They have been observed and described by many geologists.

Nearly everywhere the bedding of the clay is inclined at angles of 2° to as much as 20°, mainly owing to irregularities of the surface on which it was deposited. The bedding dips away from bedrock hills, and slopes off on either side of hills of till as if the material had been draped over each underlying high place. At a few places the beds are crumpled and distorted, as if they had slumped or slid when still saturated with water or had been shoved by floating ice masses. No sure evidence was observed in this area that the clay and silt were overridden by ice as reported elsewhere in Maine (compare page 191 and figure 33 of Perkins in Leavitt and Perkins, 1935).

Except for some thin strata of clay clearly interbedded with the older shore deposits, the material is very similar to clay cored by the Corps of Engineers in the channels between Estes Head and Lubec, and is considered to be part of the same stratigraphic unit.

Older Shore Deposits. Overlying the marine clay and silt are several separate bodies consisting mostly of bedded sand and gravel, principally on Moose Island and Deer Island. A few patches of beach shingle, not within the area studied, occur about 200 feet above sea level; the bodies described here lie below about 100 feet.

These deposits are of rather well-sorted, clearly stratified sand and gravel, generally in beds slightly concave upward and locally crossbedded. The deposits have lithologic and topographic features strongly suggesting that they are the result of shore processes acting on unconsolidated material within the zone of near-shore wave, tide, and current action. They are considered to represent the shore deposits of a temporary sea stand at about 90 feet above the present level, and are derived mainly from bodies of outwash.

Recent Deposits. At and near present sea level are modern beach deposits whose characteristics reflect the nature of the adjoining bedrock or other material at the beach head. At a few localities are bodies of brown, peaty organic matter one to two

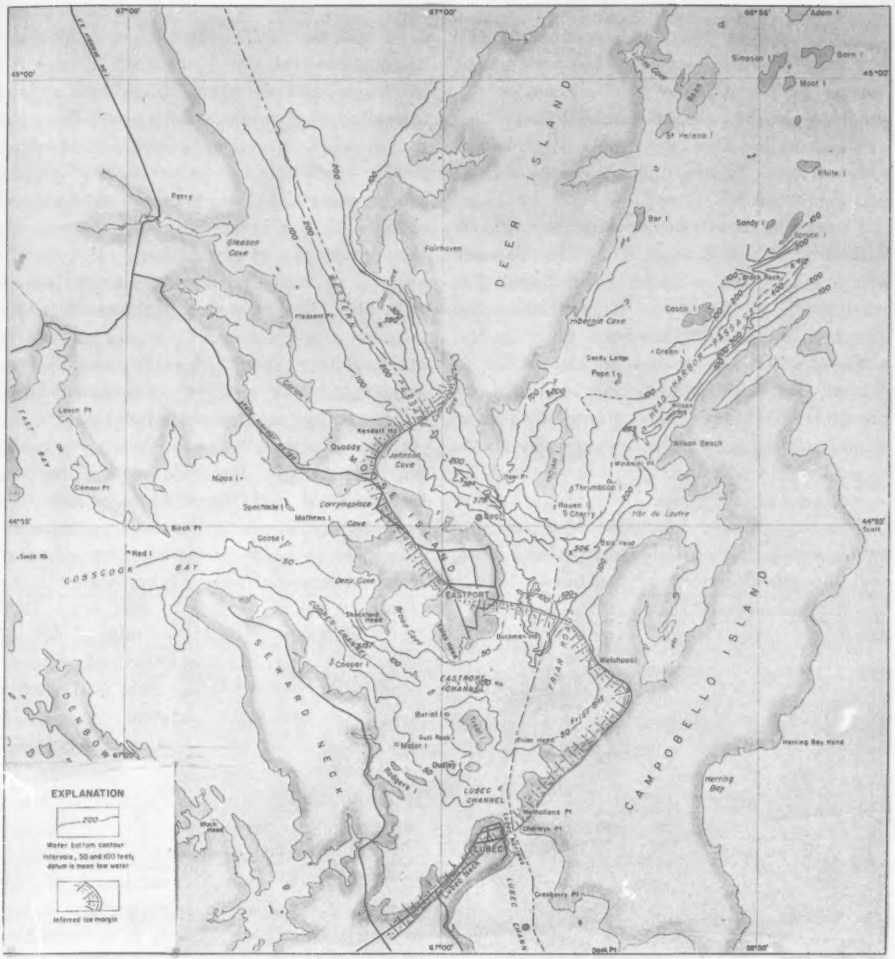

FIGURE 2. Map of vicinity of Eastport, Maine showing generalized water-bottom contours and inferred position of ice margin.

feet thick. These are exposed at low tide in the slopes of present-day beaches and may indicate a late slight rise of sea level.

Topography of the Ocean Bottom

As determined from old wire-line and other soundings made available by the United States Coast and Geodetic Survey, the submarine topography reveals significant features (see FIGURE 3). The floors of Cobscook Bay, Johnson Bay, and Friar Roads are smooth and gently sloping, and they have very little gradient; the maximum depths are about 100 feet. In contrast, the floors of Western Passage and Head Harbor Passage, although they have some smooth areas, are generally more irregular, and have rather deep channels and locally closed depressions substantially more than 100 feet deep. In Western Passage are two

"deeps," one at 390 feet, the other at 379. In Head Harbor Passage the outstanding feature is the apparently straight channel, reaching depths of more than 400 feet. West of Head Harbor Passage, on the Deer Island side of Pope Island, the bottom is smooth and about 100 feet deep.

These features, together with the information from core borings that the bedrock channel reaches a depth of at least 273 feet south of Eastport, suggest that the deeps in Western Passage are close to the bedrock surface, and that the deposition of glacial material formed the high places, created the closed depressions, and otherwise modified the original topography.

Geologic History

The sequence of unconsolidated deposits as exposed, the broad features of the land, and the configuration of the ocean bottom lead to the following inferred geologic history.

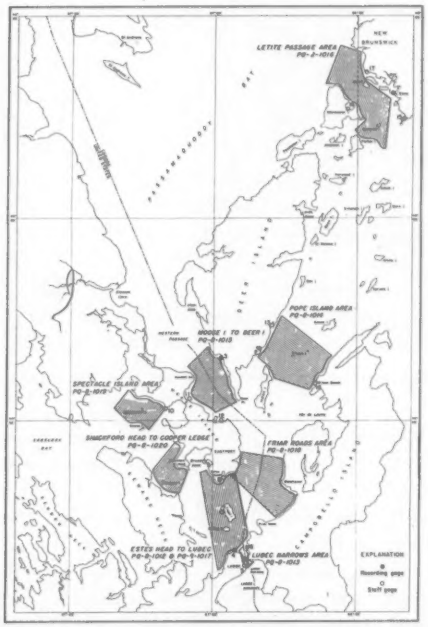

FIGURE 3. Map showing location of areas of sonic sounding traverses. (From Geological Survey duplicated report.)

The accumulation, consolidation, and deformation of the older Silurian and Devonian rocks was followed by a long period whose latest and—with respect to the present study—most significant event was the development of a stream drainage pattern and the excavation of rather deep valleys. The pattern of this drainage system coincides with that of the present channels in the area, and is reflected in a general way in the present ocean bottom (FIGURE 2). The main valley lay along what is now Western Passage and continued north along Head Harbor Passage. The principal tributary passed through Cobscook Bay, between Estes Head and Treat Island, and north across Friar Roads to the main valley.

In Pleistocene time, the ice advanced over this rugged topography, which had a maximum relief of 700 to 800 feet. There were probably several periods of ice advance, but there is clear record of only one. The ice moved generally from northwest to southeast, and during advance it smoothed and scoured the bedrock. It may have overdeepened the stream valleys locally, but probably it did not greatly modify the existing topography by erosion.

At maximum extent during the Pleistocene, the ice edge lay southeast of Nova Scotia, at least 125 miles from the vicinity of Eastport. Either at a halt in retreat, or at the end of a readvance, the ice edge is considered to have lain across the Eastport area on a line running roughly as follows (FIGURE 3): along Lubec Neck and across the Lubec Narrows, through Mulholland Point, and along the west shore of Campobello Island about as far as Welshpool, thence across Friar Roads to Moose Island, and across Moose Island to near Kendall Head where it turns northward, crossing Western Passage to Cummings Cove. From here, at this time, it may have lain along the west side of Deer Island as far north as

Clam Cove, but farther north evidence is not found. Previously the ice had melted back across the Head Harbor Passage channel, and the edge also may have halted or readvanced temporarily across the area between Pope Island and Deer Island. There is no known evidence on land, however, for such a halt.

During the postulated halt or readvance, the outwash deposits were laid down and morainal material accumulated. This was not an instantaneous process, of course, and the deposits were not exactly contemporaneous everywhere. They represent the same glacial episode, however. Sea level may have been substantially higher, perhaps 100 to 150 feet, than at present with respect to the bedrock surface; and the ocean may well have washed the ice front. Under these circumstances the greatest thicknesses of deposits would have been on those land areas and in the portions of the present channels that were at and just beyond the ice edge.

As the ice left the area, or soon after, the sea moved in. It ultimately rose to about 200 feet, with respect to the present level. During this episode the marine clay and silt were deposited. The morainal accumulation across Friar Roads at Eastport was evidently so large that much of the clay was trapped in Cobscook and Johnson Bays, although some clay occurs outside these bays. Subsequently, when recoil of the crust from ice loading became effective, the land rose to a position of temporary stability, with the sea at about 90 feet above present level. At this position the outwash deposits came within the range of tidal and wave action, and parts of them were re-

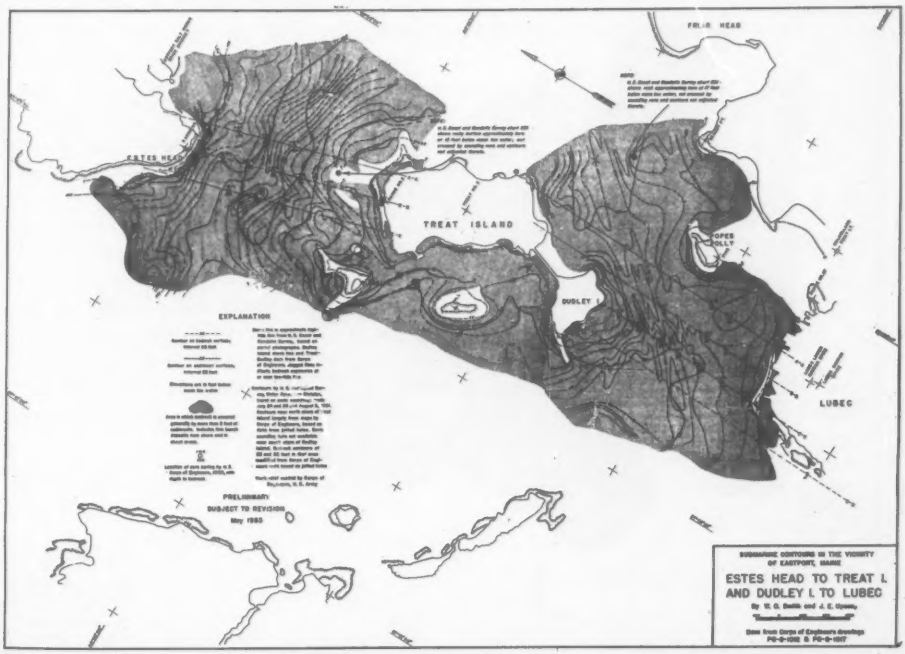

FIGURE 4. Map showing bedrock and water-bottom topography in the channels between Eastport and Lubec. (From duplicated report of Geological Survey in cooperation with Corps of Engineers.)

worked to make the older shore deposits here mapped. Later on the land rose to about its present position, and the present shore features were developed.

Distribution of Deposits from Interpretation of Sonic Data

Much of the inferred occurrence of submerged sediments was substantiated by the sonic sounding operations. These operations covered eight areas shown in FIGURE 3. In one of these, between Estes Head and Treat Island (FIGURE 4), where Army core data were available, the maximum depth of the bedrock is a little more than 300 feet below mean low water. This bedrock is overlain by a maximum of about 200 feet of marine clay and silt, as cored. From Shackford Head to Cooper Ledge, to the west and "upstream" on the submerged drainage, the maximum depth to bedrock was found to be about 230 feet below mean low water. In Friar Roads, next "downstream" from the Estes Head–Treat Island channel, the maximum depth to bedrock is about 330 feet, and overlying sediments form a smooth floor at a depth of about 100 feet. In the area from Moose Island to Deer Island (FIGURE 5), on the main drainage through Western Passage, the maximum bedrock depth is a little below 400 feet. Sediments as much as 250 feet thick cover an irregular bedrock surface. They seem to thin out to not much more than about 100 feet at the south end of the passage. Wash borings made by Peter Dexter Cooper in Johnson Cove, Moose Island, penetrated appreciable thicknesses of sediment, mostly sand. In Head Harbor Passage, southeast of Pope Island, somewhat scantier data indicate a relatively thin

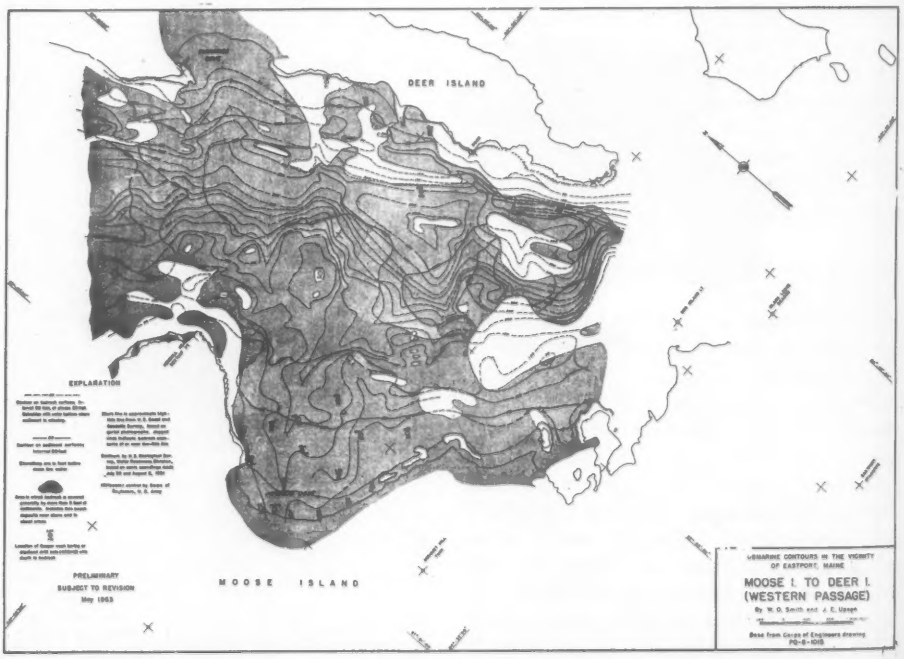

FIGURE 5. Map showing bedrock and water-bottom topography in Western Passage. (From duplicated report of Geological Survey in cooperation with Corps of Engineers.)

and narrow thread of sediment in a bedrock channel whose deepest part is more than 400 feet below mean low water. Northeast of Pope Island, sediments, locally more than 100 feet thick, form a smooth, even sea floor. Where not cored, the lithology of these deposits is not known. They are thought to be mostly sand and some gravel in most of the channels, but largely clay in the channel extending from Shackford Head to Cooper Ledge.

Conclusions

The data here described and interpretations made, suggest certain possible conclusions of geologic interest. First, the ice margin here postulated may represent the limit of readvance of one of the later Wisconsin stages. Indeed, Perkins (see page 160 and map, Leavitt and Perkins, 1935) postulated a position of the ice margin in Cutler, a short distance south of Lubec Neck, about in line with a southern extension of the margin here postulated. Second, the ice was evidently nearby when the marine clay was deposited; hence, the seashore must have been either at or close to the ice front. Third, the shore features marking a sea level at about 95 feet indicate a period, not necessarily very long, of constant relative position of land and sea. This evidence suggests a halt in crustal recoil, or some other combination of factors that would result in movement of both land and sea level in the same direction and at the same rate. Fourth, the bedrock configuration fits a stream system that must have been formed before Wisconsin ice invasion, and whose base level is now more than 400 feet below present sea level.

If the base level for this system was about at sea level at the beginning of glaciation, and if drowning is the result of ice loading alone, then something more than 400 feet of crustal recovery remains to be accomplished in the vicinity of Eastport. This estimated recovery is nearly twice the amount of recovery accomplished so far, or about 60 per cent of the total. It seems excessive in comparison with the relative amount of recovery estimated to remain for the Gulf of Bothnia in Fennoscandia (see page 416, Flint, 1947) which is about 30 per cent. On the other hand, if crustal recovery is largely complete, then an appreciable part of the drowning would appear to be owing to crustal deformation from causes other than ice loading.

References

ALCOCK, F. J. 1946. Map 964 A, Campobello, New Brunswick. Can. Geol. Survey.

BASTIN, E. S. & H. S. WILLIAMS. 1914. Description of the Eastport quadrangle, Maine. U. S. Geol. Survey, Geol. Atlas, Folio 192.

FLINT, R. F. 1947. Glacial geology and the Pleistocene epoch. Wiley. New York.

GOLDTHWAIT, L. 1949. Clay survey, 1948. In Report of the State Geologist, 1947-48. Maine Development Commission.

LEAVITT, H. W. & F. W. PERKINS. 1935. Glacial geology of Maine. Maine Technol. Expt. Sta. Univ. Maine, Bull. 30(2).

PERRY, S. C. & F. J. ALCOCK. 1945. Preliminary map 45-1, St. George, Charlotte County, New Brunswick. Can. Geol. Survey.

SMITH, W. O. & H. B. NICHOLS. 1953. Mapping water-saturated sediments by sonic methods. Sci. Monthly, 72(1):36-41.

SMITH, W. O., J. F. UPSON and others. 1952. Preliminary report on the Passamaquoddy bedrock survey—July-August 1951. U. S. Geol. Survey. Duplicated report in open files.

SECTION OF BIOLOGY *

SOME LONGEVITY RECORDS OF VERTEBRATES**

By ROSS F. NIGRELLI***

How old does an elephant get? This question is frequently asked by visitors to the Bronx Zoo, and presumably at other zoological parks throughout the world. The potential age of an elephant is between 50 and 55 years, and the record for an Indian elephant at the Bronx Zoo is 42 years. We know the age of this elephant simply because it was kept that long in captivity. As yet there is no sure way to determine the age of many species of animals other than to observe "marked" individuals. For example, we owe our thanks for a longevity record of one turtle to Edward Baker Kenyon, who at the age of 19 years etched his initials on the plastron of a Carolina box turtle in 1844. This turtle recently (1953) turned up alive at the Bronx Zoo. It was sent in by another youngster, Billy Johnson, who found it on his grandfather's farm in Hope Valley, R. I., a half mile from where Edward Kenyon lived. The date would make the turtle 109 years old but, after careful examination by herpetologists at the Bronx Zoo, the American Museum of Natural History, and at the University of Florida, it was concluded that the minimum age of this turtle must be 129 years (Oliver, 1953 b).

The determination of age in animals is also of considerable interest to biologists, gerontologists, and conservationists. The symposium held in this Academy in 1953 on *Parental Age and Characteristics of the Offspring* (Strong, 1954) indicates at least one important facet of this problem. The speakers on this program will show others.

In conservation of animals, it is obvious that *age* and not *size* is the essential criterion in attempts to legislate ecologically and economically important species. Thus, the rosefish (*Sebastes marinus*) of the north Atlantic takes 10 years to reach 10 inches. In contrast to this, it is known that the milk fish (*Chanos chanos*), indigenous to the shallow waters of the Indo-Pacific, will grow 20 inches in one year.

The rate of growth, maturity, and senescence is not known for the majority of the fish species. Many Cyprinodonts and Gobiids are "annuals;" all adults of one generation die before the next generation grows up. Most of these species live in a tropical environment (Meyers, 1952). There are considerable differences in the reproductive ability of fish. Some species may reproduce relatively frequently in their life span while others pass through a cycle in which reproduction results in the death of the parent fish. Thus, a female rainbow trout (*Salmo gairdneri*) has been nutured in captivity for 14 years and during this time has been stripped of her eggs 10 to 12 times. On the other hand, the pink salmon (*Oncorhynchus gorbuscha*) of the Pacific coast ascend streams in the fall to spawn and die. The eggs hatch in fresh water in the spring and almost immediately the fry migrate to sea, all returning to fresh water simultaneously 18 months later, also to spawn and die.

There are some records of longevity of animals kept in captivity. Many of these records are probably inaccurate since their true age could not be determined, even at autopsy, because of lack of exact methods. Whether or not many of the "old" animals would have reached the age indicated under natural conditions is a matter of conjecture. It is probable that many of them would have met an "untimely" death by predators or

* The Section of Physics and Chemistry held a meeting on March 2, 1954 at which a paper entitled "Preparation of Ferrites for Physical Measurements" was read by Francis E. Vinal. No abstract of this paper had been received at the time of publication.

** This paper, illustrated with lantern slides, was the first of four papers in a symposium on Age Determination in Animals presented at the meeting of the Section on March 8, 1954.

*** New York Aquarium, New York Zoological Society, New York, N.Y.

could not have survived adverse environmental conditions because of changes in physiological activities which result from aging. It should be emphasized that life in captivity is an unnatural one, even though some conditions may be favorable while others, *e.g.* confinement, are not beneficial (see Flower, 1935; Hediger, 1950). Hediger believes that the only criterion indicative of suitable biological conditions in captivity is successful breeding. He does not say, however, whether or not this factor makes for longer life. Orton (1929) suggests that "The longevity of some aquatic animals in confinement may, perhaps, be due to their avoidance of the reproductive strain."

Suffice to say here that many of the longevity figures, some of which are reported below, have not been recorded in animals under natural conditions.

(1) Some Longevity Records of Fishes in Captivity

Seasonal ring formation in scales, otoliths, and vertebrae are most often used in age determination in teleosts. Some of the records reported are from direct observation of "marked" specimens in captivity. Some figures were obtained from records* in the New York Aquarium; others from Flower, 1935.

Silurus glanis	European catfish	60 years
Anguilla anguilla	European eel	55
Cyprinus carpio	Carp	50
Hippoglossus hippoglossus	Halibut	30-40
Carassius auratus	Goldfish	30
*Lepidosteus osseus**	Gar pike	24
*Amia calva**	Bowfin	24
*Roccus lineatus**	Striped bass	24
Cristovomer naymacush	Lake trout	24
Clupea harengus	Herring	18-19
Stizostedion vitreum	Walleye pike	15
Micropterus dolomieu	Smallmouth bass	14
Gadus morrhua	Codfish	13 years
Salmo salar	Atlantic salmon	13
Esox lucius	Northern pike	10-14

(2) Some Longevity Records of Amphibians

Since many amphibians pass through metamorphosis, age determination must be divided into two stages: from hatching to the stage preceding metamorphosis; from metamorphosis to maturity and later life. The records indicated below are only for adults kept in captivity, and are taken from Flower (1936). There are no reliable meristic characters in the adult amphibian. It is well known, however, that stages in the development of the frog are directly dependent on temperature. The Shumway stages for *Rana pipiens* are growth stages at various intervals of time at 18°C.

Megalobatrachus japonicus	Giant salamander	55 years
Bufo bufo	European toad	36
Cryptobranchus alleganiensis	Hellbender	29
Triturus palustris	Crested newt	28
Amphiuma means	Amphiuma	27
Siren lacertina	Greater siren	25
Triturus pyrrhogaster	Japanese newt	25
Ambystoma tigrinum	Tiger salamander	
	Neotenic larva	25
	Adult	16
Rana catesbiana	North American bullfrog	16
Xenopus laevis	African clawed toad	15
Bufo americanus	American toad	10-15
Rana clamitans	Spring frog	10
Necturus maculosus	Mud-puppy	9
Hyla versicolor	Tree frog	7
Rana pipiens	Leopard frog	5

The potential longevity of the European toad has been estimated at 36 years, although this is doubtful; potential longevity of frogs is around 10 years.

(Continued)

(3) Some Longevity Records for Reptiles

Some of the meristic characters used for age determination in reptiles are as follows: growth rings of laminae of shell and certain long bones, number of radii in osteodermal ornamentations in skinks (see Oliver, 1951), and number of rattles in rattlesnakes. The growth rings in the shells of turtles and tortoises are apparently good for ages from one to fifteen years; after this age the markings are not reliable. The number of rattles in rattlesnakes are also not dependable since they are easily broken off. A one-year-old snake may have four to five rattles, a 2-year-old may have five to eight. More recently, Petter-Rousseaux (1953) has shown that the ring formations in the skull bones of *Natrix*, and presumably in other species of snakes, can be used in determining age.

Some of the records indicated below are taken from Flower, 1937, Oliver, 1953 a, b, Perkins, 1953 and from data collected by Dr. James Oliver, Curator of Reptiles, New York Zoological Society.

Testudo elephantopus	Galapagos tortoise	177 years, plus
Testudo gigantea sumeirei	Marion's tortoise	152 (maybe 150)
Terrapene carolina	Carolina box turtle	138
Testudo graeca	Greek tortoise	125
Alligator mississippiensis	Alligator	56
Kinostemon subrubrum	Pennsylvania mud turtle	38 plus
Caretta caretta	Loggerhead turtle	37 plus
Eunectes murinus	Anaconda	29
Sphenodon punctatus	Tuatera	28 plus
Epicrates cenchira maurus	Rainbow boa	27
Naja melanoleuca	Black-lipped cobra	24 years
Constrictor constrictor	Boa constrictor	23
Akistrodon piscivorus	Cotton mouth moccasin	21
Chelydra serpentina	Snapping turtle	20 (maybe longer)
Helodema suspectum	Gila monster	20
Crotalus atrox	Diamondbacked rattlesnake	16

(4) Some Longevity Records for Birds

There are no definitive reports on age determination in birds. Young birds can be distinguished from older and mature birds by coloration, growth, size, and shape of plumage; development of sternal bone has been used to a certain extent. Ornamental feathers in sexually mature birds often appear at a definite age, e.g., in peacocks in their third year. The age figures listed below are taken from Flower, 1938; from Crandall, 1949; and from the records of the New York Zoological Society as compiled by Lee Crandall, General Curator Emeritus.

Bubo bubo	Eagle owl	68 years
*Cacatua galerita**	Greater sulphur crested cockatoo	56
Vultur gryphus	Condor	52
Aquila chrysaetus	Golden eagle	46
Larus argentatus	Herring gull	41
Anser anser domesticus	Domestic goose	35 (?)
Branta canadensis	Canadian goose	33
Columba livia domestica	Domestic pigeon	30
Struthio camelus	Ostrich	27
Seleucides ignotus	12-wire bird of paradise	20

(5) Some Longevity Records for Mammals

With the exception of the Monotremata and the Edentata, the age of most mammals probably could be determined from eruption

* Claims have been made that parrots live to 100 years. According to Crandall, 1949, the 100-year-old record has not been substantiated.

(Continued)

dates of teeth and from the tooth structure at various periods of their lives. Except for certain domestic animals, however, there is a dearth of information on age determination. The figures given below are taken from Flower, 1931; from Bridges, 1935; and from the records of the New York Zoological Society as compiled by Lee Crandall, General Curator Emeritus.

	Potential Age	*Age of Animals in Bronx Zoo*
Elephants	50-55	42
Rhinoceroses	45-50	
Hippopotamus	40-50	49 plus
Equidae	35-40	21-22 plus
Giraffes	30-35	
Bears	35	28-32
Deer	30-35	23
Echidna	30	
Camels	25-30	
Felidae	25-30	
Chimpanzees	25-30	
Bovidae	25	
Canidae	20-30	
Sea lions	25	
Pigs	20-25	
Bats	20	
Mice and rats	5-10	

References

BRIDGES, W. 1935. Patriarchs in the Zoological Park. Bull. N.Y. Zool. Soc. 38: 89-98.

CRANDALL, L. S. 1949. Not nine lives—but long ones. Animal Kingdom. N.Y. Zool. Soc. 52: 161-162.

FLOWER, S. S. 1931. Contributions to our knowledge of the duration of life in vertebrate animals. V. Mammals. Proc. Zool. Soc., London. (1): 10-234.

FLOWER, S. S. 1935. Further notes on the duration of life in animals. I. Fishes: as determined by otoliths and scale readings and direct observations on living individuals. Proc. Zool. Soc., London. (1): 265-304.

FLOWER, S. S. 1936. Further notes on the duration of life in animals. II. Amphibians. Proc. Zool. Soc.. London. (1): 369-394.

FLOWER, S. S. 1937. Further notes on the duration of life in animals. III. Reptiles. Proc. Zool. Soc., London. (1): 1-37.

FLOWER, S. S. 1938. Further notes on the duration of life in animals. IV. Birds. Proc. Zool. Soc., London. (1): 195-235.

HEDIGER, H. 1950. Wild Animals in Captivity: i-ix, 1-207. Butterworths Scientific Publications. London.

MEYERS, G. S. 1952. Annual fishes. Aquarium Journal. 23: 125-141.

OLIVER, J. A. 1951. Ontogenetic changes in osteodermal ornamentation in skink. Copeia. 2(June): 127-130.

OLIVER, J. A. 1953a. The oldest inhabitant of the zoo. Animal Kingdom. N.Y. Zool. Soc. 56: 76-78.

OLIVER, J. A. 1953b. Young Billy Johnson's old box turtle. Animal Kingdom. N.Y. Zool. Soc. 56: 154-156.

ORTON, J. H. 1929. Reproduction and death of invertebrates and fishes. Nature. 123(3088): 14-15.

PERKINS, C. B. 1953. Longevity of snakes in captivity in the United States as of January 1, 1953. Copeia. (4): 243.

PETTER-ROUSSEAUX. 1953. Recherches sur la croissance et le cycle d'activité testiculaire de *Natrix natrix Helvetica* (Lacepède). La Terre et la Vie, (3): 175-223.

STRONG, L. C. 1954. Parental age and characteristics of the offspring. (A symposium) Ann. N.Y. Acad. Sci. 57: 451-614.

AGE DETERMINATION IN MOLLUSCS*

By HAROLD H. HASKIN**

Age determination in molluscs has been largely concerned with species of economic importance, including such bivalves as clams, scallops, oysters, and fresh-water mussels, and such predatory gastropods as the boring snails. Such studies have generally been designed to provide growth and mortality data necessary for the management or control of the populations.

The methods of age determination employed to date may be conveniently grouped into three categories as follows: (1) size-frequency study; (2) the interpretation of growth interruption lines on shells or other parts of the animal; and (3) experimental methods involving the release and recovery of marked individuals. Age determinations of molluscs based on (1) or (2) alone are frequently doubtful, and check determinations using at least one of the other methods are desirable.

These methods may best be explained by illustrating their use. A very recent use of the size-frequency method is that of Posgay (1954) described in his studies of the growth of the sea scallop, *Pecten grandis*, in Cape Cod Bay. Collections from the scallop beds fished by commercial scallopers yielded animals ranging in length from approximately 5 mm. to 170 mm. These specimens were grouped in five mm.-size classes and plotted in a size-frequency diagram. Five modes were evident at 20, 50, 75, 100, and 130 mm. Assuming the addition of a new generation to the population each year, the collection then apparently contains five year-classes, and the difference between successive modes indicates the annual increment in length.

This size-frequency method has been much used in fishery investigations. It has the principal advantage of enabling the investigator to estimate the age composition of the population directly from his catch without more complex studies. There are, however, several difficulties and weaknesses in this method: (1) the complete absence of a year-class, or its poor representation in the population, may lead to error in the estimated ages; (2) in the absence of other information the age of the smallest year class is unknown. For example, as regards the sea scallop, is the 20-mm. year-class zero, one, or two years old?; (3) the older year-classes show a greater spread of sizes, overlapping of classes and, finally, a complete obscuring of the modes. The weaknesses of the size-frequency method may be partially overcome by its repeated application to the population at intervals so spaced that changes in the modes can be followed. Posgay in his sea-scallop study also employed the third method, the release and recovery of tagged individuals. This procedure was followed in the case of individuals measuring 80 mm. and over. The increases in length during the known periods of time between release and recovery (approximately one year) were measured directly. These measurements provided additional data on one-year length increments, agreeing well with the deductions from the size-frequency determinations for the larger sizes of scallops.

Posgay states that growth interruption lines, method two, on sea-scallop shells are unreliable indicators of age, principally because they may be caused by such disturbances as dredging, or by warming to approximately 16° C. or cooling to 3° C. This occurrence of a summer growth check, in addition to the more usual winter check, follows from Posgay's interesting discovery that the sea scallop has an unusually low optimum temperature for growth at about 9° C.

*This paper, illustrated with lantern slides, was the second of four papers in a symposium on Age Determination in Animals presented at the meeting of the Section on March 8, 1954.

**Department of Zoology and N. J. Oyster Research Laboratory, Rutgers University, New Brunswick, N. J.

A classical example of the use of growth interruption lines in age determination of bivalves is the study by Weymouth (1923) of the Pismo clam, *Tivela stultorum*. Weymouth demonstrated that a growth check occurred regularly every winter and was clearly evident on the shell. The validity of the growth checks as indicators of age was carefully established by a direct study of the Pismo clam population over a period of several years, and by the recovery of marked specimens. This paper illustrates well the precautions to be taken in application of the growth-interruption line method. Many observers have assumed that in various bivalve species one interruption line is added per year. It is necessary to establish this assumption by supplementary observations of the given species in the particular situation before the interruption lines can be equated to annual rings. For example, Turner (1954) has shown that in the moon shell, the predatory gastropod *Polynices duplicata*, shell-growth checks are completely unreliable as indicators of age. Growth in this animal is correlated with available food supply as shown both by field observations and laboratory experiments.

Growth indicators other than checks on the surface of bivalve shells may appear in molluscan structures. Nelson (1942) has used the lines on the ligament scars of *Crassostrea virginica* shells as indicators of age. According to Nelson the oysters in Delaware Bay shift their ligaments posteriorly once each winter, thus leaving one line per year on the ligament scar. More recently, Kubo (1953) has determined age in the marine gastropod, *Babylonia japonica*, the Japanese topshell, by use of the operculum. The operculum is enlarged by marginal growth centered on its "nucleus," and the cessation of growth during each winter results in an annual check. According to Hubendick (1948) opercular rings in the gastropod *Viviparus viviparus* also correspond to periods of hibernation. Crozier (1918) established the reliability of transverse growth lines on the plates of the amphineuran, *Chiton tuberculatus*, as an index to age.

The application of the third of these methods, the release and recovery of marked individuals, to the problem of age determination in *Venus mercenaria*, the quahog clam or hard clam of our east coast will be discussed in some detail. In 1947 a program to explore the feasibility of hard-clam culture was begun at Rutgers. A primary problem was the determination of growth rates in the areas potentially suitable for such culture. Preliminary study of the native populations indicated: (1) that size-frequency relations were an unreliable index to age because of sporadic "sets" of juveniles and the depletion of various size classes owing to heavy fishing pressure; and (2) that growth-checks on the shells could not be interpreted with confidence, at

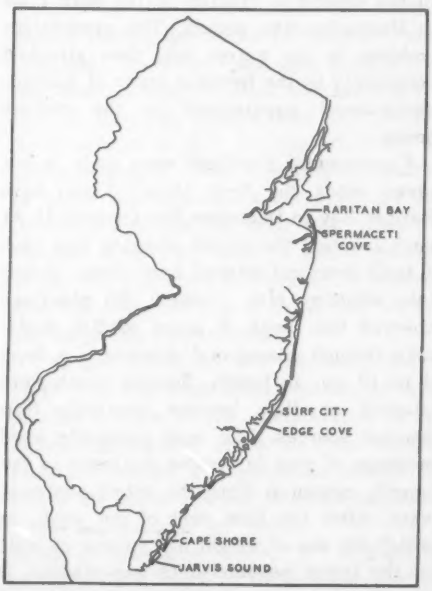

FIGURE 1

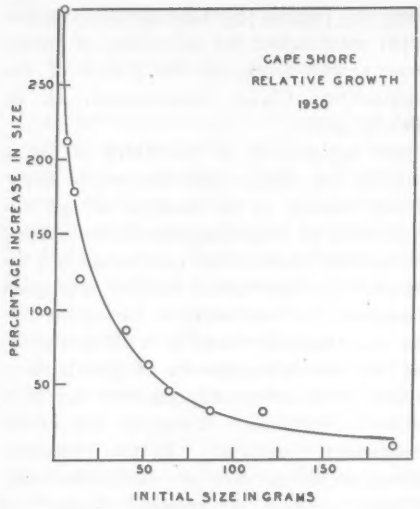

FIGURE 2

least without further knowledge of the populations. Belding (1912) successfully employed the growth interruption line method in his extensive studies of the hard clam in Massachusetts waters. The growth-rate problem in our waters was then attacked principally by the frequent study of marked, sequestered populations in the various areas.

Experimental plantings were made in six areas along the New Jersey Coast from Raritan Bay to Delaware Bay (FIGURE 1). At each location the initial planting was from 1 to 2 thousand marked hard clams sorted into arbitrary size classes. All plantings covered the range of sizes readily available through commercial sources, *i.e.* from 4 to 10 cm. in length. Smaller sizes were planted as they became available from special sources. The most commonly used measure of size in bivalve molluscs is the length, measured along the antero-posterior axis. After the first year of our work, in which the use of weight and volume as well as the linear measurements was studied, it was decided to use weight as a measure of size. The principal advantage of this is speed. Clams can be drained and weighed on a pan balance in the field, handling groups of 10 or 20 as quickly as two or three clams can be measured. For comparison of data with results of other workers the following empirical relation between quahog dimensions may be used.

$$\sqrt[3]{w} = 0.671\, l.$$

where w = weight in grams (or milligrams)
$l.$ = length in centimeters (or milimeters)

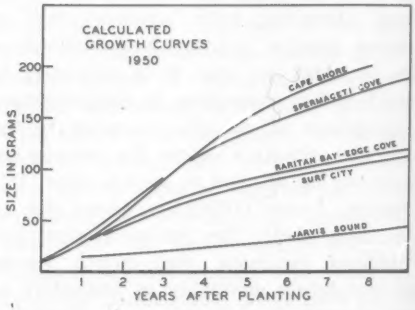

FIGURE 3

For each arbitrary size of clam in each planting, annual average increments in weight were obtained. From these increments the percentage increases in weight were calculated. The latter plotted against the initial weight gave a relative growth curve, FIGURE 2. This type of curve is particularly valuable, for from it may then be

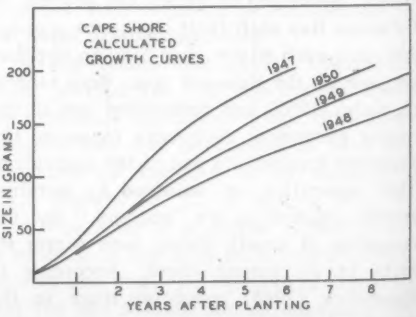

FIGURE 4

derived a cumulative growth curve for the entire size range covered by the plantings (upper curve, FIGURE 3). FIGURES 2 and 3 are based on data covering the 1950 growth season for the hard clam. FIGURE 3 shows the growth curves expected if all the years were like 1950. This method, then, obviously does not provide reliable long-term growth curves for the areas indicated, but the method is useful in comparing 1950 growth rates in the various areas and with the rates for other years. FIGURE 4 presents similar curves derived for four individual years for the Cape Shore and shows the variation in growth that occurred from year to year. The curve labelled "1950" closely approximates the mean-growth curve for the four years shown in FIGURE 5 and probably is close to the long-term mean-growth curve for the area. From such a curve, then, one can approximately "age" the native population in the area and also derive other values of use in the management of the population (absolute growth curve, FIGURE 5).

A major weakness of such a growth curve is that it cannot be safely extrapolated beyond the range of sizes in the experimental plantings. For the first three years of our studies only small numbers of clams below 10 grams of weight were obtainable. The age of the 10-gram clams was in doubt, so the first growth curves (FIGURES 3 and 4) were based on the planting of 10-gram seed clams. In 1950 large numbers of small

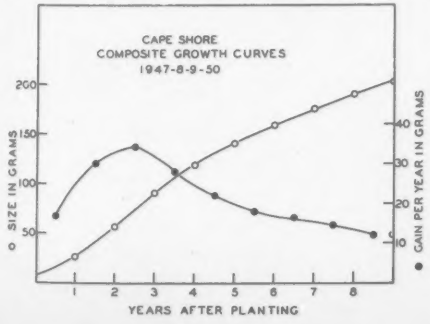

FIGURE 5

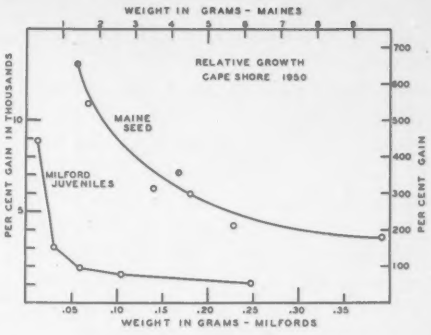

FIGURE 6

juveniles from laboratory spawnings were provided by Doctor Victor Loosanoff and his associates of the United States Fish and Wildlife Service Laboratory at Milford, Conn. During the same season, seed quahogs ranging down to one gram in weight were provided by Dana Wallace of the Maine Department of Sea and Shore Fisheries. Applying the same experimental techniques with these juveniles and seed clams as described for the larger sizes, the relative growth curves presented in FIGURE 6 were obtained. These indicate that a hard-clam may reach a size of about one gram at the end of its first season, and that in one more season it will be approximately 10 grams in weight. Thus, counting the season in which the hard clams are produced and in which they set, as their first year, the 10-gram clams, at least in better growing areas, are 2 years old. Using this information, the lower portion of the growth curves may be safely constructed.

The growth curves and the direct observations of the experimental plantings also provide a basis for the interpretation of the growth-interruption lines on the shells. FIGURE 7 shows six hard-clam shells on which the major growth interruptions have been accentuated by pencil. "A" is a native of Spermaceti Cove, "B" is a native of Edge Cove. Both of these areas are important in the commercial production of hard clams. If one assumes that the major

interruption lines are annual rings, the Spermaceti Cove clam at about six years is much larger than the Edge Cove native at at least 11 years. The crowding of the rings beyond the 10th makes an accurate count impossible. Without other evidence one would be skeptical of the value of these rings. FIGURE 3, based on experimental plantings, indicates that the deduction of ages based on the interruption lines of clams in these two areas is reasonable. Clams "C" and "D" in FIGURE 7 are part of a population of Maine seed transplanted to Spermaceti Cove in the spring of 1950. They were harvested three years later and the three known seasons of growth check well with the expected growth based on the calculated curve (FIGURE 3). An additional interruption ring was apparently formed during 1952. Clams "E" and "F" in FIGURE 7 are from an experimental planting on the Cape Shore of Delaware Bay from July 1947 to September 1950. These clams clearly show an extra interruption line formed during the summer of 1949. In all five summers studied at this location, growth was slower than in either spring or fall but the summer of 1949 was the only one in which a clear-cut interruption ring was formed. It appears from such observations as these that growth-interruption lines on hard clams in New Jersey waters are of limited value in age determination.

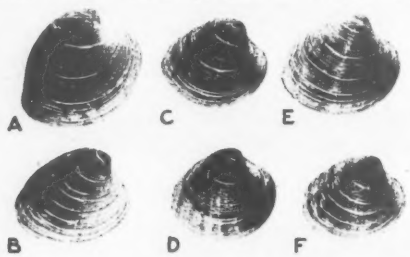

FIGURE 7

Summary

The age of molluscs has been determined by three principal methods. All of these methods have their special advantages and weaknesses. The size-frequency method and the use of growth-interruption lines are particularly useful in providing information rapidly on the age composition of the population. The reliability of the information so obtained must be checked independently. The release and recovery of marked individuals provides completely reliable growth information within the size ranges of the animals recovered. From such information, size-age relationships of the population may be determined. This method is comparatively time-consuming and is recommended for age determinations only where good recoveries may be expected or where checks on findings by the other methods are desired.

References

1. BELDING, D. L. 1912. The quahaug fishery of Massachusetts, Marine Fisheries Series 2. Massachusetts Dept. of Conservation.
2. CROZIER, W. J. 1918. Growth and duration of life in *Chiton tuberculatus*. Proc. Natl. Acad. Sci. U. S. 4(11): 322-25.
3. HUBENDICK, B. 1948. Uber den Bau und des konzentrischen Operculartypus bei Gastropoden. Archiv. Zool. 40(A 10): 1-28.
4. KUBO, I. 1953. Age determination of the *Babylonica japonica* (Reeve) an edible marine gastropod, basing on the operculum. J. Tokyo Univ. Fisheries. 34: 199.
5. NELSON, T. C. 1942. The oysters. In the Boylston Street Fishweir. 2. chap. 3. Papers of the Robert S. Peabody Foundation for Archaeology.
6. POSGAY, J. A. 1954. Private communication from Woods Hole Oceanographic Institution, Woods Hole, Mass.
7. TURNER, H. 1954. Private communication from Woods Hole Oceanographic Institution, Woods Hole, Mass.
8. WEYMOUTH, F. W. 1923. The life history and growth of the Pismo Clam, *Tivela stultorum*, Mawe. Fish Bulletin No. 7. Calif. Fish & Game Commission.

AGE DETERMINATION OF FISH*

By ALFRED PERLMUTTER**

Until the late 1800's, most of the information on determining the age of fish was limited to observations on individuals of species kept in ponds for esthetic reasons or for food as, for example, the goldfish and the carp. While markings on scales and other bony parts of fish had been noticed by biologists for many years, and while theories had been advanced as to the correlation of these markings with the age of the fish, it was not until 1899 that Hoffbauer[1] crystallized the theories and published a paper on the age of carp as determined from their scales. Since then, there has been a rapid development in techniques for aging fish. The subject has received added impetus because of its importance as a tool in the recently born science of Applied Fishery Biology. To the fishery biologist, information on age and growth of the fish is essential before a clear picture of the status of a stock can be drawn and before conservation measures can be recommended. Age data is correlated with sexual maturity data to furnish age at maturity information, which is of importance in establishing size limits. From age and growth data, it can be determined what year-classes of fish are being taken by the fishery, the degree to which dominant year-classes are contributing to the catch, and whether fish are being replaced as fast as they are removed by the fishery. In our lakes and streams, the suitability of certain waters for planting particular species of fish can be gauged by the degree of growth as measured by the age and growth studies.

The story of the step-by-step improvements in techniques and comprehensive bibliographies of papers on age determination of fish are contained in papers by Lee,[2] van Oosten,[3] Graham,[4] and Mohr.[5,6,7]

It is not my purpose here either to present an historical account of the development of techniques in age determination of fish or a complete bibliography on the subject, but rather to describe briefly means for determining the ages of fish. Growth studies of fish are intimately associated with methods for age studies and will be included in our discussion. Three general approaches are in use for determining the ages of fish; namely, the Petersen method, the marked fish method, and bony structure method. The Petersen method[8] is based on length-frequency distributions of fish. It assumes that each age class is distributed normally and that in a total length-frequency curve of distribution of all ages of fish contained in the population, the various year classes will appear as individual modes. Actually, in practice, the Petersen method must be used cautiously. In general, the length-frequency distribution of the young of the year, the 0 group of fish or perhaps the yearling fish, the 1+ fish, when included in the length-frequency curve of the population as a whole, will show a distinctive mode. Beyond these age groups, however, there is an increase in the standard deviation or degree of spread of sizes of fish within the year class, and the extent of overlap of the various age frequencies is usually so large that the modes for the different age frequencies are hidden. An exception to this increase may be found in instances when there is an unusually successful year class which may be dominant in the population for several years. In such an event, this year class may be recognizable for several years by its prominent mode on the total length-frequency curve. I might mention here that, in actual practice, most of the length-frequency curves for an age group that I have examined are not normal in distribution but

*This paper, illustrated with lantern slides, was the third of four papers in a symposium on Age Determination in Animals presented at the meeting of the Section on March 8, 1954.

**Marine Fisheries Division, New York State Conservation Department.

have a slight tendency toward negative skewness.

The marked fish method involves the use of bodies of fish of known ages in which fins of the fish have been clipped either singly or in various combinations, or tags have been inserted to identify them. The fish are measured when marked and released in their natural environment and are remeasured during periodic intervals of recapture. Theoretically, it is possible using this technique, to determine the age as well as the rate of growth of all fish which can be marked in quantity and recaptured each year in large enough numbers to plot length-frequency distributions. Hatchery reared salmon fingerlings, which are fin clipped before they move out to sea, can accordingly be identified as being of a certain age when they return to the river to spawn several years later. In actual practice, however, there is one major disadvantage to the method. Fin clipping is only practicable where fish, when caught, are individually handled; the clipped fins may otherwise be overlooked. Salmon, to a great extent, satisfy the required conditions. Ideal conditions may also be found in work on trout in streams, and on bass and other of the fish inhabitants of smaller ponds and lakes, or where the biologist himself has developed a procedure for effecting recapture of sufficient fin-clipped fish to furnish the desired information.

Tags for marking fish in age and growth studies also have their limitations. Good summaries of the type of tags employed in fish work are contained in a paper by Rounsefell.[9] Despite the years of work devoted to design of fish tags, there is still no completely satisfactory tag which will remain on a fish from the juvenile stage throughout its life. From tagged fish of known ages, however, it is possible to calculate the growth of these same fish each time they are recovered; moreover, the technique serves as a check on the third method of age and growth determination in fish, through use of the scale or of some bony structure of the fish.

By and large, the most common and versatile method of determining piscatorial age and growth is by use of some bony structure or of the scales. In actual practice, the scales have proved the most useful structure in studies of age and growth. Mostly, the bony structures have been employed only as a last resort, when scales are difficult to read, or are lacking, as in the lake sturgeon.[10] Also, bony structures have been used as a check on the validity of age determinations estimated from scales, particularly in the case of older fish. The most serious drawback in the use of bony structures in the study of age and growth in fish is that the animal must be killed and in some measure dissected. The death of the animal ends further experimental study of the fish. The need for some degree of mutilation of the fish may reduce or destroy its market value should it be part of the catch of a commercial fisherman. Further, in most instances, preparation of the various bones for use in age study is more difficult than preparation of the scales for the same purpose. For example, Appelget and Smith[11] in preparing vertebrae of the channel catfish removed objectionable tissue from the centra of the vertebrae by placing each bone in a solution consisting of 0.7 per cent pepsin and 0.2 per cent hydrochloric acid, and incubating them at 100° F. for 24 hours. The fact that various bones of fish, however, do show differential concentrations of bony materials which can be correlated with age and annular growth, has been used by investigators to study age and growth in fish. The most common bone employed is the sagitta, the largest of the three otoliths or ear stones present on each side in the sacculus of the inner ear, usually referred to as the otolith. Annular rings may be very distinct on the otolith and can sometimes be read directly

without further preparation. Often, soaking this bone for a period of time in glycerine, oil of wintergreen, oil of cloves, or other essential oils emphasizes the differences in the rings and makes the determination easier. Sometimes it is necessary to split the otolith horizontally through its center and add a drop of glycerine to the surface to bring out the contrasting growth rings. Or it may be necessary to grind down the otolith at each end until just a horizontal section through the center remains. Actually, the best technique to use must be worked out for each species individually, and it is interesting to note that even here the same technique may not be good throughout the range of the species. For example, the growth rings of the otoliths of the winter flounder, *Pseudopleuronectes americanus*, taken in New Brunswick waters, could be read directly and with comparative ease merely by breaking them in half horizontally at their center, embedding them in plastelene, and adding a drop of glycerine to the broken surface; while otoliths taken from the same species in New York waters and treated in the same manner proved difficult to read. Some other bones which have been used in age determination in fish include the opercular bones,[12, 13] the vertebral centra,[11] the pectoral spine,[14] the pectoral rays,[15] and the supra-occipital crest.[16]

Whether or not bony structures or scales are used in determining age and growth in fish, it is necessary to set up criteria to determine the relationship of the growth rings to age. I shall go into this problem more fully in the discussion of age and growth determination in fish through studies of the scales.

The principal kinds of scales found on most fish are the cycloid and ctenoid types. Generally, the Malacopterygian or soft-rayed fish have cycloid scales, and the Acanthopterygian or spiny-rayed fish have ctenoid scales. The principal difference between the two kinds of scales is the presence of ctenii, or spines, on the posterior margin of the ctenoid scale. A structure common to both types of scales is the focus, which is somewhere close to the center of the scale in the cycloid type, but may be more posterior in the ctenoid type. It represents the first scale platelet formed. Extending out from the focus to the the margin of the scales are lines termed radii. Surrounding the focus are concentric striations called circuli. It is the circuli which are used in determining the age of the fish.

According to Van Oosten,[3] use of the scale method is dependent on three major conditions. First, the scale number must remain constant and the same scale must be present throughout the life of the fish. In most species of fish, growth is accompanied by an increase in the size of the scale, and the scale number is so constant that various scale counts are used taxonomically to distinguish between species and subspecies. Further, unless injured, the same fish scale is retained throughout the life of the animal. As evidence, it can be seen that the central portion of the scales of older fish are identical in structure with that of the younger fish. If through accident scales are lost, they are replaced by clearly recognizable regenerated scales in each of which the focus is lacking, being replaced by a large central area without circuli, somewhat irregular in shape, and often rough in appearance. The size of this central area depends on the age of the fish at the time the scale was lost, being larger for fish which have lost scales relatively late in life.

A second condition upon which the scale method for age determination in fish is founded is that growth of the scale is proportional to growth of the fish. In actuality, there is seldom complete proportionality of these two factors, but the discrepancy only shows up in use of scales for back-calculating the size of a fish at each annulus.

The third condition as outlined by Van Oosten is that the year mark or annulus, as its name implies, should truly form each year and at about the same time of the year. Actually, from aquarium and tagging experiments on fish, and from numerous studies of their age and growth, there is no question of the validity of the annuli as true year marks. Nevertheless, for each species of fish studied, it is necessary to establish objective criteria independently for determining the annuli in that species.

Probably the best way to demonstrate how to determine the age and growth of fish from scales is to go through the routine of a typical study. The first step is to determine the area of the body from which the scale samples should be taken. For this purpose, the body of the fish is arbitrarily divided into several sections, and scales are taken from the midportion of each of these sections for two or more specimens. These scales are examined for uniformity of shape, and data is taken on the longitudinal distance from the focus to the anterior margin of the scale, and on the total number of circuli. The region of the body which shows scales having the greatest number of circuli and having the greatest longitudinal distance from the focus to the anterior margin of the scale, and is a spot bearing scales that are fairly uniform in shape is selected as the "scale patch." Selection of this scale patch is based on the assumption that those scales which are largest and contain the greatest number of circuli were the ones first formed on the fish and therefore reflect the most growth of the fish from the time of scale formation until the scale was collected.

After determination of the scale patch, a series of scales are collected from the population of fish to be studied. Collection taken at random often give a predominance of scale material in the younger age groups and little material among the older age groups. To obtain adequate data on the older fish it may be necessary, in some instances, to take stratified samples of scales from fish at different size intervals. Several scales removed from each fish with a knife or forceps are placed in a small coin envelope. Pertinent data, such as locality, length and sex of fish, *etc.*, are recorded on the envelope and the specimens are now ready for mounting. Different mounting techniques are in use, and scales from each species present an individual problem as to which technique best brings out the structure of the scale and the annuli. If the mucus of the fish has been wiped off carefully in the scale patch area before sampling, it may not be necessary to clean the scales before mounting. If not, scales must be soaked in water and the debris rubbed off with a small brush. A drop of ammonia added to the water assists in the cleaning process. Temporary mounts, either wet or dry, sometimes are adequate for study of the scale. Permanent mounts are also used and are of two general types. In the first type the scale itself is placed on a glass slide in a medium of a different refractive index from the scale, such as sodium silicate (waterglass), a glycerine-gelatine mixture, white karo syrup, or euparol. In the second type, developed by Nesbit,[17] the sculpturings on the scale are impressed on a plastic material.

After a decision has been reached as to the best type of mount, the next question is what apparatus should be used to examine the scale. Although a good binocular microscope may be employed in determining age from the scales in many species of fish, it is not nearly as convenient in making measurements or counts when used in conjunction with an eyepiece micrometer or camera lucida, and is much harder on the eyes of the investigator than various types of projection apparatus or "scale-reading machines" that have been developed, from which an enlarged image is pro-

jected on some type of screen.[18, 19, 20] Measurements of either part or the whole of the projected magnified image of the scale are easily made directly with a ruler or are marked off on strips of cardboard for measurement at some future time.

Everything is now ready for the study of the ages of the fish as demonstrated by their scales. From the numerous age studies that have been made in the past, certain criteria have been established which indicate annuli or year marks. These may be a series of discontinuous circuli, or a cutting over of the circuli marking a slowing down or cessation of growth, or a band of narrow-spaced circuli denoting a slowing down of growth, possibly in winter, followed by a band of wider-spaced circuli denoting increased growth, generally during the following spring and summer. The experienced investigator can generally spot such apparent signs of year marks, but it is still necessary for him to test the validity of his observation. This test can be made by counting the number of circuli and measuring the distance between the last apparent year mark and the end of the scales from samples taken throughout the year and preferably from fish within a relatively small size range. If the investigator's designation of the year mark is valid, then the distance between this mark and the edge of the scale and the number of circuli should show a gradual increase throughout the growing season, and then, at a certain period, show a sudden decrease. This sudden decrease would result from the formation of a new annulus. Not only is the validity of the pattern designated by the investigator as an annulus thus corroborated, but this knowledge also enables him to determine at what time of the year the annulus is found. Generally, in the temperate zone, annulus formation is associated with reduction in water temperature accompanied by decreased activity of the fish. However, unusual environmental conditions may also result in formation of checks in growth which, in some instances, may be difficult to distinguish from true annuli and may lead to some error in age studies, the amount of error depending on the extent to which such "false checks" exist in the sample and the degree of difficulty in distinguishing them from a true annulus.

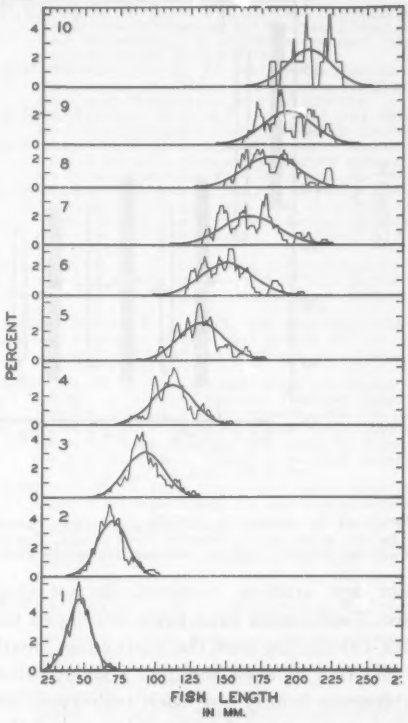

FIGURE 1. Length-frequency distributions of rosefish from the Browns Bank area of western Nova Scotia for each annulus of annuli 1 to 10. Lightly drawn irregular curves are the actual frequency distributions smoothed by a moving average of five. Heavily drawn smooth curves are the normal curves fitted to the actual frequency data.

Once objective criteria for determination of the annulus of any species of fish has been worked out, there remains only the tedious process of examination of the scales from each of the fish, the recording of the data, and the tabulation of results.

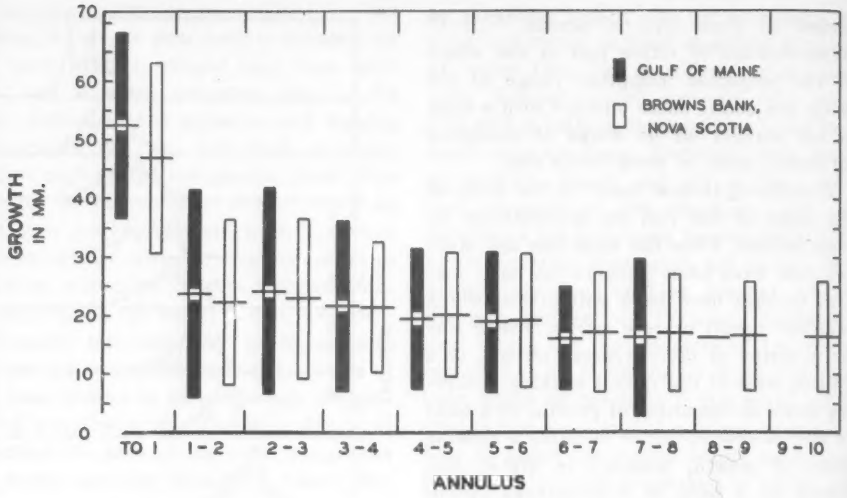

FIGURE 2. Growth, in millimeters, between annuli of immature rosefish taken in the Gulf of Maine and off the Browns Bank area of western Nova Scotia. The horizontal lines represent the average growth to each annulus and the vertical bars two standard deviations above and below the mean.

Most age studies, however, do not stop here. Techniques have been developed for back-calculating from the scales the length of the fish at each annulus. I should like to discuss briefly one such technique. As has been mentioned previously, one of the conditions for use of the scale in age and growth studies is that its growth is proportional to growth in length of the fish, and that usually the relationship is not strictly proportional. If it were, a line drawn through the points representing the relationship of fish length to scale size would pass through the zero intercept of the x axis, where x represents the fish lengths. In this instance, the size of a fish at each annulus in its life history could be computed from the scale sample merely by using the simple proportion

$$L : Lx = S : Sx$$

where: L is the length of the fish when the scale sample was taken; Lx is the unknown length of the fish at annulus x; S is the size of the scale as measured from the focus to the anterior margin; and Sx is the distance from the focus of the scale to annulus x.

Since the relationship of the size of scale to the size of fish more often can be described by a straight line which shows a positive or negative intercept value at the x axis, this intercept value must be used as a correction in the preceding formula. Thus:

$$Lx - C : L - C = Sx : S .$$

Often the relationship of scale size to fish length is curvilinear. Transformation of the arithmetic values of both characters to logarithms enables a straight line to be fitted to the data. The resulting logarithmic intercept value on the x axis now serves as a correction in the formula $Lx - C : L - C = Sx : S$, and logarithmic values are substituted for the arithmetic values of L and S before computation.

An example of the results obtained by using this technique of back-calculation of lengths at the various annuli is shown in a study of the age and growth of rosefish, *Sebastes marinus*, on the Browns Bank

area of Nova Scotia[21] (FIGURE 1). Scales from 104 fish were read, and back-calculations were made. Based on these calculations, the length-frequency distribution of fish at each annulus from annulus one to ten was determined. From the same calculations, the growth in length of the fish between each annulus was computed (FIGURE 2).

In conclusion, let me point out that this discussion of age and growth in fish has been deliberately over-simplified to stay within the allotted time, and also because I feel that presentation of the finer technical points would be more proper in a symposium devoted exclusively to the subject of age and growth in fish.

References

1. HOFFBAUER, C. 1898. Die Alterbestimmung des Karpfen an seiner Schuppe. Allgem. Fisch. Ztg. 23: 341-343.
2. LEE, R. M. 1920. A review of the methods of age and growth determination in fishes by means of scales. Ministry Agri. Fish., Fish. Invest. Series 2. 4(2): 1-32.
3. VAN OOSTEN, J. 1929. Life history of the lake herring (*Leucichthys artedi* Le Sueur) of Lake Huron as revealed by its scales, with a critique of the scale method. Bull. U.S. Bur. Fish. 44: 265-428.
4. GRAHAM, M. 1929. Studies of age determination in fish. Part II. A survey of the literature. Ministry Agri. Fish., Fish. Invest. Series 2. 11(3): 5-50.
5. MOHR, E. W. 1927. Bibliographie der Alters-und Wachstums-Bestimmung bei Fischen. J. conseil permanent intern. exploration mer. 5(1): 88-100.
6. MOHR, E. W. 1930. Bibliographie der Alters-und Wachstums-Bestimmung bei Fischen. 2. Nachtrage und Fortsetzund. J. conseil permanent intern. exploration mer. 5(1): 88-100.
7. MOHR, E. W. 1934. Bibliographie der Alters-und Wachstums-Bestimmung bei Fischen. 3. Nachtrage und Fortsetzung. J. conseil permanent intern. exploration mer. 9(3): 377-391.
8. PETERSEN, C. G. J. 1891. Eine Methode zur Bestimmung des Alters und Wuchses der Fische. Mitt. deut. Seefischerei Ver. 11: 226-235.
9. ROUNSEFELL, G. A. & J. L. KASK. 1945. How to mark fish. Trans. Am. Fisheries Soc. 73: 320-363.
10. HARKNESS, W. J. K. 1923. The rate of growth and food of the lake sturgeon (*Acipenser rubicundus* Le Sueur). Pub. Ont. Fish. Res. Lab. 18: 15-42.
11. APPELGET, J. & L. L. SMITH, JR. 1951. The determination of age and rate of growth from vertebrae of the channel catfish, *Ictalurus lacustris punctatus*. Trans. Am. Fisheries Soc. 80: 119-139.
12. LE CREN, E. D. 1947. The determination of the age and growth of the perch (*Perca fluviatilis*) from opercular bone. J. Animal Ecol. 16(2): 188-204.
13. MCCONNEL, W. J. 1952. The opercular bone as an indicator of age and growth of the carp *Cyprinus carpio* Linnaeus. Trans. Am. Fisheries Soc. 81: 138-149.
14. SNEED, K. C. 1951. A method for calculating the growth of channel catfish, *Ictalurus lacustris punctatus*. Trans. Am. Fisheries Soc. 80: 174-183.
15. CUERRIER, J. P. & G. ROUSSOW. 1951. Age and growth of lake sturgeon from Lake St. Francis, St. Lawrence River. Report on material collected in 1947. Can. Fish. Cult. 10: 17-29.
16. MENON, M. D. 1950. The use of bones other than otoliths in determining the age and growth-rate of fishes. J. conseil permanent intern. exploration mer. 16(3): 311; 335.
17. NESBIT, R. A. 1934. A convenient method for preparing celluloid impressions of fish scales. J. conseil permanent intern. exploration mer. 9(3): 373-376.
18. VAN OOSTEN, J., H. J. DEASON & F. W. JOBES. 1934. A microprojection machine designed for the study of fish scales. J. conseil permanent intern. exploration mer. 9(2): 241-248.
19. TESTER, A. L. 1940. A modified scale projector. Trans. Am. Fisheries Soc. 70: 98-101.
20. MOSHER, K. H. 1950. Description of projection device for use in age determination from fish scales. U.S. Fish Wildlife Service, Fishery Bull. 54: 405-407.
21. PERLMUTTER, A. & G. M. CLARKE. 1949. Age and growth of immature rosefish (*Sebastes marinus*) in the Gulf of Maine and off western Nova Scotia. U. S. Fish Wildlife Service. Fishery Bull. 45: 207-228.

AGE DETERMINATION IN MAMMALS*

By CHARLES P. GANDAL**

As regards mammals, a variety of methods are used in determining the age of different species. The standard criteria in use include: (1) external appearance and features; (2) horns and antlers; (3) baleen plates and *corpora lutea* in whales; (4) epiphyseal closure; (5) the baculum; and (6) teeth.

Under each of these headings I shall give examples of the work that has been done using that particular method. For some of the more common methods I have naturally limited myself in the number of species mentioned, as it would be foolish and a waste of time to quote eruption dates of teeth in all species for which this information has been gathered. To me the method itself and the fact that it can be applied to a variety of species is of prime importance.

In most of the common domestic animals it is not too difficult a matter to determine age within fairly definite limits. Wild animals present a problem, however, in that it is difficult to examine a sufficient number of "known age" specimens to establish accurate criteria for aging "unknowns" of that species.

1. External Appearance and Features

The first method consists of approximating age by external physical characteristics such as size, weight, condition, coloration, and attitude. Two examples of this method as applied to domestic animals are outstanding:

(1) The "old dog" that anyone can tell is old by just watching him walk past. His hair may have turned gray about the muzzle, his gait is stilted and slow, his skin hangs in folds, the coat has lost its shine—he just looks old.

(2) The "old gray mare"—who certainly isn't what she used to be. Her once showy gray coat has become a dirty white, and this condition, along with her sway-back profile and lagging gait, leaves no doubt as to her being aged.

With regard to wild animals the following would fall into this classification:

(1) In the opossum, first-year females are distinguished from breeders by their rusty color, scant fur, and lack of mammary gland development. [1]

(2) In the porpoise, the umbilical scar of subadults is a definite pigmented depression, whereas in adults it is difficult to see. [2]

(3) In California jack rabbits, weekly growth measurements determined from curved averages have been used. [3]

Over all size and weight are good general criteria in most mammals, but the effects of different environmental conditions must be carefully evaluated, especially when this method is applied to widely separated populations.

2. Horns and Antlers

Horns and antlers are grouped together because of their similarity as appendages, although they are in actual structure and physiology quite different.

(1) Horns in cows of the domestic breeds are used to give a fairly close approximation of age. Owing to metabolic changes brought about by the yearly calving process, concentric rings are laid down at the base of the horn at approximately yearly intervals. [4, 5] Therefore, in aging cows, the number of rings plus two gives a rough estimate of age.

(2) Regarding antlers, a general increase in their weight, size, and number of points may be noted up to eight or nine years, at which time they reach maximum size, then slowly regress. This change parallels that of the body weight, which also reaches a maximum at eight or nine years. [6, 7] Here again we must be exceedingly careful in

*This paper was the fourth of four papers in a symposium on Age Determination in Animals presented at the meeting of the Section on March 8, 1954.

**New York Zoological Society, New York, N. Y.

interpretation, as the availability of an adequate food supply and the mineral content of the feed have a great effect on antler growth in a particular season.

3. *Baleen Plates and* Corpora Lutea *in Whales*

Whalebone whales are known to show two very interesting annular developments which can be used to determine age.

The first of these developments is the number of *corpora lutea* found in the ovary of mature females.[8] Different investigations have placed the number of *corpora lutea* at from one to three per year, but even with this difference in figures a distinct correlation can be shown.

The other method is based on records of the configuration of the baleen plates, which are grouped according to growth levels and are used to approximate the age of whalebone whales.[9] Baleen plates are rows of transverse plates of keratin hanging from the roof of the mouth and serving as strainers on which the plankton and krill are caught as the whale moves through the water with its mouth open.

4. *Epiphyseal Closure*

Much use has been made of the time at which complete ossification, or epiphyseal closure takes place in the long bones of mammals. To use a single example, the cottontail rabbit is known to undergo closure of the humeral epiphysis at nine months.[11,12] The time of the closure may be determined either by an X ray on which the epiphyseal cartilage, if present, will show as a horizontal V-shaped notch, or in the denuded bone as a groove across the anterior proximal surface of the bone. This data is of great interest to conservation workers, as it enables them to determine what per cent of a year's kill is made up of rabbits born that spring. There is a program based on information of this sort under way at present in New York State which, unfortunately, has not been too well supported by the hunters.[11]

5. *The Baculum*

The baculum, or *os penis*, has been used to classify the age groups of many animals. In the River Otter, four age groups were determined by this method:[13] (1) old adults; (2) young adults; (3) immature; and (4) very young. This calculation was made by using and index based on the sum of the products of length (in millimeters) times weight (in grams), and length times volume (in cc.).

Adults can be distinguished from subadults also by a flaring of the proximal portion of the body and a rough tapering head.

In the Michigan beaver, three age classes were found:[14] (1) yearlings; (2) two and three years; and (3) four years and over. These classifications were made on the basis of four criteria, any one of which was satisfactory alone, but the use of all four together gave the most precise results: (1) length; (2) weight; (3) dorso-ventral height at proximal face; and (4) head to tail length ratio.

It was also found that the following skull measurements were of great value in determining the age of beavers:[14] (1) zygomatic width; (2) greatest length of mandible; (3) height from ventral surface of mandible to the upper limit of coronoid process; and (4) basilar length of hensel.

6. *Teeth*

The use of teeth for determining age in animals dates back many centuries. Tooth features most commonly relied on in this connection are: (1) eruption dates; (2) wear; and (3) coloration. To these features must be added the presence of "annular rings." In the elephant seal, thin ground sections of the canine teeth taken at the alveolar level reveal definite concentric rings, which are accounted for by nutritional disturbance created during the fasting which accompanies mating and moulting.[17] By means of

these sections, age can be determined in the male to 20 years and in the female to 13 years. It is entirely possible that some of our common hibernating mammals may show similar rings upon further investigation.

With regard to eruption and wear, the horse best illustrates the use of these criteria.[4, 5] The permanent incisors appear at two and a half, three and a half, and four and a half years of age, starting with the centrals. As these teeth grow out of their alveolar sockets, the black "cup" formed by the infundibulum is worn away and disappears from the central incisors at six years, from the intermediate incisors at seven years, and from the lateral incisors at eight years. After eight years, calculating the age of a horse is pure approximation.

At 10 years Galvayne's Groove may be seen starting at the gumline of the upper lateral incisors. At 15 years this groove extends halfway down the tooth, and at 20 years it reaches the occlusal surface of the tooth. At 25 years it is evidenced only on the lower half of the tooth, and at 30 years it disappears entirely. During this period the incisors lose their rectangular shape and slowly become triangular. Moreover, the angle between the upper and lower incisors becomes progressively less and less (in horses under eight the incisors are nearly vertical), and in a horse over 25 years old the angle may actually be less than 90°.

With regard to coloration, the carnivores exemplify the possibility of using the brown discoloration and tartar deposits on teeth as the basis for making a very rough estimate of age—usually serving to distinguish subadults and young adults from older specimens.

I feel quite certain that if enough tooth specimens, of known age, of any wild animal could be obtained, it would be possible to set up a standard for determining the age of any individual of that particular species, using eruption dates, wearing features, and coloration.

References

1. PETRIDES, G. A. 1949. Sex and age determination in the opossum. J. Mammalogy. 30(4): 364-378.
2. SCHEFFER, V. B. 1949. The dall porpoise. *Phocoenoides dalli*, in Alaska. J. Mammalogy. 30(2): 116-121.
3. HASKELL, H. S. & H. G. REYNOLDS. 1947. Growth, developmental food requirements, and breeding activity of the California jack rabbit. J. Mammalogy. 28(2): 129-136.
4. HIUDEKOPER, R. S. 1896. Age of the Domestic Animals. F. A. Davis.
5. SISSON, S. 1910. A Text-book of Veterinary Anatomy. Saunders. Philadelphia, Pa. and London.
6. HUXLEY, J. S. 1926. Annual increment of antlers of red deer. Proc. Zool. Soc. London. 2: 1021.
7. HUXLEY, J. S. 1931. The relative size of antlers in deer. Proc. Zool. Soc. London. 2: 819.
8. MACKINTOSH, N. A. 1946. The natural history of whalebone whales. Smithsonian Inst. Annual Repts. : 235.
9. RUUD, J. T. Further studies on the structure of the baleen plates and their application to age determination. Hvalradets Skrifter (Scientific Results of Marine Biological Research.)
10. TOWNSEND, C. H. 1930. Twentieth century whaling. Bull. N.Y. Zool. Soc. 33(1): 3-32.
11. DELL, J. 1954. Aging of cottontail rabbits through closure of the humeral epiphysis. Personal communication. (New York State Wildlife Research Laboratory.)
12. HALE, J. B. 1949. Aging cottontail rabbits by bone growth. J. Wildlife Management. 13(2): 216-225.
13. FRILEY, C. E. JR. 1949. Age determination, by use of the baculum, in the river otter, *Lutra c. canadensis* Schreber. J. Mammalogy. 30(2): 102-110.
14. FRILEY, C. E. JR. 1949. Use of the baculum in age determination of Michigan beaver. J. Mammalogy. 30(3): 261-267.
15. SCHEFFER, V. B. 1940. Growth of the testes and baculum in the fur seal, *Callorhinus ursinus*. J. Mammalogy. 31(4): 384-394.
16. WRIGHT, P. L. 1947. The sexual cycle of the male long-tailed weasel, (Mustela frenata). J. Mammalogy. 28(4): 343-352.
17. LAWS, R. M. 1952. A new method of age determination for mammals. Nature. 169(4310): 972-973.
18. CAHALANE, V. H. 1932. Age variation in the teeth and skull of the whitetail deer. Cranbrook Institute of Science Scientific Publication No. 2.
19. SEVERINGHAUS, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. J. Wildlife Management. 13(2): 195-216.
20. SATHER, J. H. 1954. The dentition method of aging muskrats. Natural History Miscellanea No. 130.
21. LEESE, A. S. 1927. Treatise on the One-humped Camel. Haynes. Stamford, Lincolnshire, England.

*DIVISION OF MYCOLOGY**

THE GENUS *ACTINOPLANES* AND ITS RELATIVES**

By JOHN N. COUCH***

The genus *Actinoplanes* was discovered accidentally while looking for chytrids in soil samples sent from the Philippines and other far eastern areas, near the end of the last world war. When first seen these forms were mistaken for members of the Chytridiales, but closer study soon showed that they were related to the Actinomycetales yet differed from these in having sporangia and swimming spores, hence the name *Actinoplanes*. Using essentially the same methods described in detail by Couch,[1, 2, 3] for the collection and culture of the Chytridiales, we now have obtained in pure culture about 50 isolates representing about 30 species from the soils of many climates ranging from Alaska to the tropics. Several species have also been isolated by the soil dilution methods described by Jensen in 1930, using his dextrose-casein agar, but better results have been obtained with 3 per cent plain agar, since *Streptomyces* and other molds grow less vigorously on the plain agar. However, the most rapid and best techniques so far found are modifications of the chytrid-isolating methods to which reference has already been made.

In this procedure, a small amount of soil, not to exceed a level teaspoonful, is put in a sterile Petri dish and flooded with sterile water. As soon as the dirt has settled, two or three pieces of boiled *Paspalum* grass leaves are put in the dish in such a manner that each piece of leaf is floating just under the surface or only partly submerged. After four to seven days the leaves are examined with a binocular dissecting microscope (× about 100) under a strong direct light. If *Actinoplanes* is present, it can be recognized by the white glistening sporangia formed in the air at the surface of the water. Next, a small piece of the leaf bearing sporangia is cut off and transferred to 3 per cent plain agar, and then single sporangia are dissected out from which pure cultures can be made. The pollen of *Liquidambar* has also been used in this connection with good results. It has the advantage over cooked leaves of floating on or just below the surface and, furthermore, *Actinoplanes* appears on the pollen in three to four days. It is easy to pick up a pollen grain with *Actinoplanes* under the binocular dissecting microscope, transfer it to plain agar, and dissect out single sporangia for the preparation of pure cultures. From the pure stock cultures, transfers are made to various culture media in the usual way for the study of growth characters and sporangial production.

On *Paspalum* leaves and parts of other plants in water all the species of *Actinoplanes* grow very slowly, producing a delicate growth barely visible even after ten days to two weeks. In addition to growing throughout the leaf, the mycelium usually forms a fringe around the edge and, in some species, considerable aerial mycelium is formed on the upper surface of the leaf.

*The Section of Psychology held a meeting on March 15, 1954 at which a paper entitled "Interracial Contact and Attitude Change" was read by Daniel M. Wilner. This paper will be published in a subsequent issue.

The Section of Mathematics and Engineering held a meeting on March 19, 1954 at which a paper entitled "Engineering with New Plastic Materials" was read by William E. Holland. No abstract of this paper had been received at the time of publication.

The Section of Anthropology held a meeting on March 22, 1954. Owing to illness Meyer Fortes was unable to deliver his paper entitled "Growing Points in African Ethnography and Sociology." In its place, a paper entitled "New Horizons in South American Tropical Forest Ethnography" was read by Charles Wagley. No abstract of either of these papers had been received at the time of the publication.

The Section of Oceanography and Meteorology held a meeting on March 23, 1954 at which a paper entitled "Prediction of Cyclogenesis Affecting Eastern United States" was read by Norman E. Husbey. No abstract of this paper had been received at the time of publication.

**This paper, illustrated with lantern slides, was presented at the meeting of the Division on March 26, 1954.

***Department of Botany, University of North Carolina, Chapel Hill, N.C.

The mycelium is usually pinkish to orange but is sometimes white. The hyphae are 0.5-1.5μ thick, branched, and sparingly septate, much as in *Streptomyces* or *Micromonospora*.

Usually after a week, sporangia begin to appear on the part of the leaf that is at the surface of the water; *i.e.*, the sporangia are formed in the air, apparently never beneath the surface. In the different species, they vary greatly in size, from 5μ to 40μ, and in shape. They may be sessile or stalked, and the stalk may be straight and unbranched, or branched and twisted, with one to several sporangia at the end of each of the branches. The sporangia most frequently occur on the cut ends of the leaf, but may be formed all along the margin. In some species, they form a continuous layer over part or all of the leaf surface, giving to the leaf a whitish or pinkish powdery appearance. In mature sporangia the spores may be irregularly arranged, or arranged in more or less regular coils or in rows.

If mature sporangia are submerged in water, dehiscence begins after a few minutes to a couple of hours, perhaps caused by the swelling of an intersporal substance. In some species, the spores emerge through a small hole in the wall, and in others the wall may crack irregularly. The sporangial wall usually disappears soon after spore discharge, but in some species it persists for a day or so. Under low power the spores appear to be round, but when examined under water immersion, or in phase oil immersion, it is very difficult to find a round spore. Most are subglobose, angular, or slightly pyriform. Usually one small shiny dot is visible in each spore, though some spores show two or three spots. The spores are exceedingly vigorous swimmers but no flagella can be seen by bright light, by phase, or by the usual dark field illumination. Furthermore, the technique (osmic acid, crystal violet), so successful in staining the flagella of the lower fungi, is worthless here. We may therefore conclude that these are not ordinary fungal spores. After swimming for some time, the spores come to rest and germinate by a fine tube that quickly branches to form the mycelium.

Leaf cultures in water in Petri dishes have certain disadvantages. The chief disadvantage is the ease of contamination. But *Paspalum* grass in water is the only medium, natural or synthetic, yet tried, on which all species of *Actinoplanes* produce sporangia. Furthermore, the shapes and sizes of the sporangia of a given species remain fairly constant on *Paspalum*, and hence are of great value in distinguishing species. Growth characters on various agars, gelatin, and other media can also be used to distinguish species.

On agar, the most striking feature of many of the species is the remarkably brilliant and varied color of the cultures. The predominant colors are shades of orange, though other colors may occur. No greens, blues, or violets (except for some pale lavender sectors) have been found. Color is a very useful character in helping to distinguish species but, being subject to both genetical and environmental variations, must be used with extreme caution. The most brilliant colors are produced on Czapek, peptone Czapek, and potato dextrose agars by such species as P5, A16, and D.S. 24. P5 on Czapek at 68° C. is usually a brilliant orange, but sometimes it may be almost unpigmented. At higher temperatures the color is brownish. On nutrient agar, at 30 to 32° C. no pigment is formed, and the culture is white. Other species show equally striking color variations. Light and air, as well as the contents of the culture media, seem to play an important part in pigment formation.

The amount of growth under controlled conditions is significant in indicating species groups and differences between species. D.S.22, D.S.34, L.S.O., and 27b grow slowly and produce a relatively small

amount of growth on all culture media. These four represent a group of three distinct species characterized in part by the formation of small, spherical sporangia having nonmotile spores. "Whif" and "Ed," two very distinct species, characteristically produce small patches of growth. Others, such as D.S.24, are relatively vigorous in growth.

The surface characters vary greatly but, under controlled conditions in a given species, remain fairly stable and hence are of taxonomic value. On Czapek agar, at a temperature around 70° C. a number of species produce a flat smooth growth more or less even with the surface of the agar, while on peptone Czapek, and on potato dextrose agars, the surfaces of these same species are elevated and thrown into ridges, folds, bumps, or convolutions.

The peculiar behavior known as "sectoring" has been observed in a number of species. The "sectors" are usually wedge-shaped, and they may differ from the normal in color, in surface characters, and in the presence or absence of sporangia. One species, No. 30, which is normally orange with patches of Indian red on peptone Czapek, has produced several different variants, one of which is an albino. Several of these variants of No. 30 have been isolated by Miss Goldie-Smith and are being studied intensively by her. These have so far remained distinct from the original. Waksman[7] reports many similar variations in *Streptomyces*.

Several species of *Actinoplanes*, as for example C.T.7, K.C.H.5, and M.R.H.4, produce, at times, a very distinctive, musty odor, given off only in cultures which are forming sporangia in large quantities. Other cultures smell like freshly plowed soil and some produce other nondescript, slightly pleasant or unpleasant odors. It is of interest that similar odors have been described for the aerobic species of *Streptomyces*.

A vertical section through a six-weeks-old culture of most species shows two distinct regions: a lower region of hyphae extending horizontally through the agar and usually growing in tufts; and a top region of much compacted hyphae which extend more or less vertically. The structure of this top layer differs strikingly in different species and in the same species on different media. Several species, when grown on certain agars, particularly Czapek, form nearly straight, sparingly branched or unbranched, vertical hyphae (called palisade hyphae) which are up to two microns thick and hence often twice as thick as the ordinary hyphae. The palisade hyphae, when present, usually bear apical sporangia. In other species, horizontal hyphae are intermixed with the palisades, thus giving a lattice effect. And in still other species, distinct palisades are not formed on any agars, the top layer consisting of densely compacted, branched and entangled hyphae.

The most distinctive features of *Actinoplanes* are the sporangia and motile spores. As noted above, the sporangia of a species are constant in size and shape on *Paspalum* grass in water. The same thing is true of the sporangia of a species on a given agar. It is thus possible to distinguish between species by the size and shape of sporangia on the same agars. Some species produce abundant sporangia on certain agars while other species produce only a few or none. On different agars, the sporangia of a given species may differ in both size and shape. For example, the sporangia of C.T.7 are nearly globose on Czapek agar; while on potato dextrose agar they are elongated and considerably larger.

Under certain conditions of culture, some species of *Actinoplanes* will produce conidia, which have been confused with those of *Micromonospora*. Indeed, a non-sporangial strain of *Actinoplanes* might easily be confused with *Micromonospora*. However, we have several species of

authentic *Micromonospora* sent us by Jensen[5] and Waksman, and a considerable number of locally collected species, for comparison. The spores in *Micromonospora* are formed singly or in grape-like clusters but never in chains. The conidia of *Actinoplanes* are formed singly and also in chains. Furthermore, none of the collections of *Micromonospora* forms sporangia. Another striking difference is that, in most species of *Micromonospora*, on certain agars the sporulating surface turns black, whereas this change does not occur in *Actinoplanes*.

Several species of *Actinoplanes* when grown on certain agars, potato dextrose for example, will form a small pasty growth which, when mounted and crushed under a coverslip, separates into minute spheres, irregular rods, and short, branched, hyphal segments, much as reported for *Nocardia*. Such growth, however, is not the normal condition for any species of *Actinoplanes*. None of the species of *Nocardia*, in the Baarn and American Type Culture Collections (a total of 25), formed sporangia when grown either on any of the agars most favorable for sporangial formation or on *Paspalum* leaves in water.

It is likely that *Actinoplanes* is closer to *Streptomyces* than to either of the above genera. Indeed we think we may have the connection between these two genera in a new and undescribed genus represented by three distinct species. This genus is characterized by having sporangia bearing nonmotile spores. One of the species produces conidia in coils and also sporangia.

Our studies on *Actinoplanes* and its relatives indicate that *Actinoplanes* belongs in the Actinomycetales and is closest to *Streptomyces*. But what bearing does the discovery of sporangia and planospores have on the relationships of the entire order? The well developed mycelium, the sporangia, and the motile spores would seem to relate these forms to the lower fungi. However, the nuclear staining techniques of Robinow and De Lamater[4] show that the artifacts produced in *Actinoplanes* are like those found by Kleineberger-Nobel[6] in *Streptomyces*, and by Robinow and others in bacteria.

It has been recognized for over 50 years that the structure of the motile cells in algae, fungi, and protozoa are of prime importance in determining relationships. As already noted, the usual techniques which so clearly reveal flagella in the lower fungi and algae fail to do so in *Actinoplanes*. It required the powerful staining methods used for bringing out bacterial flagella, and the electron microscope, to reveal the flagella of this genus.* These techniques show that the flagella of the motile cells in *Actinoplanes* are similar to those of bacteria, rather than to those of the lower fungi. We cannot ignore the striking resemblance, however, of the mycelium and the sporangia of this genus to those of the chytrids, and so our conclusion is that *Actinoplanes* may represent a connecting link between the bacteria and the lower fungi.

*Preparations and electron microscope photographs by W. J. Koch.

References

1. COUCH, J. N. 1939. Technic for collection, isolation, and culture of chytrids. J. Elisha Mitchell Sci. Soc. 55: 208-214.
2. COUCH, J. N. 1949. A new group of organisms related to *Actinomyces*. J. Elisha Mitchell Sci. Soc. 65: 315-318.
3. COUCH, J. N. 1950. *Actinoplanes*, a new genus of the Actinomycetales. J. Elisha Mitchell Sci. Soc. 66: 87-92.
4. DE LAMATER, E. D. 1951. A staining and dehydrating procedure for the handling of microorganisms. Stain Technol. 26: 199-204.
5. JENSEN, H. L. 1930. The genus *Micromonospora* Orskov, a little known group of soil microorganisms. Proc. Linnean Soc. N.S.W. 55: 231-249.
6. KLEINEBERGER-NOBEL, E. 1947. The life cycle of sporing *Actinomyces* as revealed by a study of their structure and septation. J. Gen. Microbiol. 1: 22-32.
7. WAKSMAN, S. A. 1950. The Actinomycetes. Chronica Botan. Waltham, Mass.

NOTICE TO ACTIVE MEMBERS

In accordance with the Bylaws of the Academy, Article VII, Section 7, the Nominating Committee of the Council is inserting in this April issue a notice to Active Members, quoting Article IV, Section 1 of the Bylaws.

Article IV, Section 1 reads as follows:

"*Suggestions by the Members for Nominations.* Suggestions for nominations of Officers of the Academy and Members of the Council, with the exception of Sectional Chairmen, may be sent in writing by any Active Member of the Academy, addressed to the Nominating Committee of the Academy, 2 East Sixty-third Street, New York, N. Y., with the name of the proposer. To be considered, such suggestions must be received not later than September first of each year."

CONFERENCE HELD

SECTION OF BIOLOGY

"PAUL EHRLICH CENTENNIAL CONFERENCE"

MARCH 13, 1954

The Section of Biology held a conference in honor of the centennial of the birth of Paul Ehrlich. Doctor R. J. Schnitzer and Doctor E. Grunberg were the Conference Co-Chairman in charge of the meeting.

The program consisted of a presentation and papers as follows:

Saturday, March 13

Morning Session. Chairman: John A. Aeschlimann

"Opening Remarks," John A. Aeschlimann, Hoffmann-La Roche, Inc., Nutley, N.J.

Presentation of two Bronze Busts, one of Paul Ehrlich and the other of Emil von Behring, as a gift to the Academy from Farbwerke Hoechst A. G., Frankfurt (Main), Germany by His Excellency, Doctor Heinz L. Krekeler, Ambassador, The Federal Republic of Germany, Washington, D.C.

"Introductory Remarks," E. Grunberg, Chemotherapy Laboratories, Hoffmann-La Roche, Inc., Nutley, N.J.

"Ehrlich's Influence on Organic Chemistry and Biochemistry," Hugo Bauer, Department of Health, Education and Welfare, National Institutes of Health, Bethesda, Md.

"Ehrlich's Side Chain Theory in the Light of Present Immunology," Ernest Witebsky, The Buffalo General Hospital, Buffalo, N.Y.

"Anti-toxic Immunity," Bela Schick, Post-Graduate Medical Faculty, Columbia University, New York, N.Y.

"Progress of Cancer Research since Ehrlich," C. P. Rhoads, Sloan-Kettering Institute for Cancer Research, New York, N.Y.

Afternoon Session. Chairman: M. L. Tainter

"Chemotherapy of Trypanosomal Infections," C. H. Browning, University of Glasgow, Glasgow, Scotland.

"Chemotherapy of Spirochetal Infections," John A. Kolmer, The Institute of Public Health and Preventive Medicine of Temple University, Philadelphia, Pa.

"Chemotherapy of Bacterial Infections," R. J. Schnitzer, Chemotherapy Laboratories, Hoffmann-La Roche, Inc., Nutley, N.J.

"Drug Resistance," Harry Eagle, Department of Health, Education and Welfare, National Institutes of Health, Bethesda, Md.

Evening Session. Chairman: Harry Zimmerman

"Vital Staining," Nathan Chandler Foot, Cornell University Medical College, New York, N.Y.

"Blood Morphology," Paul Reznikoff, Cornell University Medical College, New York, N.Y.

The Section of Biology provides conferences for active workers in the special fields of Biology.

Attendence is limited to those invited to participate in these conferences and to interested Members of the Academy.

NEW MEMBERS

Elected March 25, 1954

SUSTAINING MEMBERSHIP

Blanchet, Romeo, M.D., Physiology, Psychodynamics. Professor of Human Physiology, Laval University, Quebec, P.Q., Canada.

Lofstrom, Dennis E., B.S., Physiology, Endocrinology. Senior Medical Student, University of Minnesota, Minneapolis, Minn.

Manov, Frank S., B.S., Operations Research. Manager, Systems Analysis Department, Missile Systems Laboratory, Sylvania Electric Products Inc., Bayside, N.Y.

Naumberg, Walter W., General Science. Layman, New York, N.Y.

Walker, Newton Field, M.D., Biology. Private Practice, El Paso, Texas.

ACTIVE MEMBERSHIP

Agranoff, Bernard William, M.D., Biochemistry. Biochemist, Naval Medical School, Bethesda, Md.

Altschule, Mark D., M.D., Physiology. Assistant Professor of Medicine, Harvard University, Boston, Mass.

Ambrose, J. W., Ph.D., Geology. Professor, Queens University, Kingston, Ont., Canada.

Bedell, Wallace C., M.D., Biology. Medical Officer, Naval Medical Research Institute, Bethesda, Md.

Begley, Bernard C., M.D., Cancer, Private Practice, San Francisco, Calif.

Berg, Roland H., B.S., Medical Sciences. Science and Medicine Editor, Look Magazine, New York, N.Y.

Brown, Ivan W., M.D., Surgery, Hematology. Assistant Professor of Surgery, Duke University, Durham, N.C.

Brush, Brock E., M.D., Thyroid, Pancreas. Senior Associate, General Surgery, Henry Ford Hospital, Detroit, Mich.

Conklin, Harold C., B.A., Anthropology, Graduate Student, Yale University, New Haven, Conn.

Dobkin, Gerald Bernard, M.A., Clinical Chemistry. Assistant Chemist, Maimonides Hospital, Brooklyn, N.Y.

Domfest, Burton S., B.A., Endocrine, Physiology. Research Assistant to Doctor A. S. Gordon, New York, N.Y.

Edgar, Martha Jane, B.A., Zoology, Biology. Teaching Fellow, Smith College, Northampton, Mass.

Ellis, Richard Akers, Ph.D., Biology. Research Fellow in Medicine, Harvard Medical School, Boston, Mass.

Elvidge, Arthur Roland, Ph.D., Biology. Associate Neurosurgeon, Montreal Neurological Institute and Royal Victoria Hospital, Montreal, P.Q., Canada.

Etsten, Benjamin E., M.D., Anesthesiology. Anesthetist-in-Chief, New England Center Hospital, Boston, Mass.

Fox, Sidney M., Ph.D., Organic Chemistry, Research Associate, E. R. Squibb and Sons, New Brunswick, N.J.

Fugitt, Charles Huntt, Ph.D., Biophysics. Head, Biophysics Division, Aviation Medical Acceleration Laboratory, Naval Air Development Center, Johnsville, Pa.

Gillis, Marvin B., Ph.D., Nutrition, Biochemistry. Supervisor, Biological Research, International Minerals and Chemical Corporation, Skokie, Ill.

Goldblum, Raymond W., M.D., Dermatology, Keratinization. Director, Dermatology Research, Army Medical Service Graduate School, Walter Reed Army Medical Center, Washington, D.C.

Gross, Jack, Ph.D., Endocrinology. Associate Professor, State University of New York Medical Center, New York, N.Y.

Henderson, Marjorie, M.A., Medical Science, State University of New York, Brooklyn, N.Y.

Hicks, James Thomas, Ph.D., Pathology, Microbiology. Assistant Professor of Pathology, University of Arkansas, Little Rock, Ark.

Holmes, William Neil, M.Sc., Endocrinology. Visiting Scholar, Harvard Biological Laboratories, Cambridge, Mass.

Hooper, Mary Elizabeth, B.A., Pathology. Research Assistant, Department of Pharmacology, Warner-Chilcott Laboratories, New York, N.Y.

Hyatt, George William, M.D., Homotransplantation of Tissue. Orthopedic Surgeon, Consultant to the Tissue Bank, Naval Medical School, Bethesda, Md.

Imber, Irving, M.D., Medicine. Instructor, School of Medicine, University of Pennsylvania, Philadelphia, Pa.

James, William Holden, Ph.D., Nutritional Biochemistry. Associate Agricultural Biochemist, Louisiana State University, Baton Rouge, La.

Jevson, Robert M., B.A. Psychology. Production Control, Motion Picture Laboratory, Brooklyn, N.Y.

Joos, Howard, A., M.D., Pediatrics. Instructor in Pediatrics, Strong Memorial Hospital, Rochester, N.Y.

Karabinos, Joseph Vincent, Ph.D., Organic Chemistry. Director of Organic Research, Blockson Chemical Company, Joliet, Ill.

Kazin, Louis E., Ph.G., Pharmaceutical Journalism. Associate Editor, Drug Topics, New York, N.Y.

Kimball, Stockton, M.D., Gastroenterology, Internal Medicine. Dean, School of Medicine, University of Buffalo, Buffalo, N.Y.

Lack, Herbert, M.D., Biology. Director, Department of Radiology, Beverly Hills Clinic, Beverly Hills, Calif.

Luisada, Aldo A., M.D., Cardiology. Associate Professor of Medicine and Director, Division of Cardiology, Chicago Medical School, Chicago, Ill.

McBee, Earl T. Ph.D., Organic Chemistry. Head, Department of Chemistry, Purdue University, Lafayette, Ind.

McCarter, John Alexander, Ph.D., Biochemistry. Professor, Head, Department of Biochemistry, Dalhousie University, Halifax, N.S., Canada.

Marengo, Norman P., Ph.D., Cytology. Assistant Professor of Biology, Hofstra College, Hempstead, L.I., N.Y.

Mollura, Joseph L., B.A., Histology, Cytochemistry. Research Worker, Cancer Research Laboratories, Francis Delafield Hospital, New York, N.Y.

Morton, M. E., M.D., Biology, Director, Radioisotope Unit, Veterans Administration Hospital, Long Beach, Calif.

Murray, Maynard, M.D., Pharmacology, Physiology. Clinical Associate, Otolaryngology, Stritch School of Medicine, Loyola University, Chicago, Ill.

Ochoa, Gonzales A., M.D., Tropical Dermatology, Mycology. Head of Laboratory, Department of Tropical Dermatology, University of Mexico, Mexico City, D.F. Mexico.

O'Dell, Daniel Herman, Ph.D., Biology. Associate Professor of Biology, East Tennessee State College, Johnson City, Tenn.

Olson, William H., M.D., Biology. Physician in Charge, Indiana State Prison, Michigan City, Ind.

Osgood, Edwin E., M.D., Biology. Professor of Medicine, Head, Division of Experimental Medicine, University of Oregon Medical School, Portland, Ore.

Oster, Robert Harold, Ph.D., Physiology, Professor of Physiology, University of Maryland, Baltimore, Md.

Pautler, Elmer Eugene, M.D., Neoplasms. Assistant Professor of Pathology and Bacteriology, University of Tennessee, Memphis, Tenn.

Pollak, Ann, M.D., Pathology. Assistant Professor of Pathology, University of Kansas Medical Center, Kansas City, Kansas.

Reichlin, Seymour, M.D., Endocrinology. Research Fellow, Department of Neuroendocrinology, Institute of Psychiatry, Maudsley Hospital, London, England.

Reisner, Alexander H., B.A., Genetics. Graduate Student, Indiana University, Bloomington, Ind.

Rodrigues, Ramon, Biology. Santiago, Chile.

Rogers, Blair Oakley, M.D., Plastic and Reconstructive Surgery, Milbank Fellow in Plastic Surgery, New York University Medical Center at Bellevue, New York, N.Y.

Roosevelt, Cornelius V. S., M.S., Mining Engineering and Earth Sciences. Consulting Engineer, Washington, D.C.

Santacross, Nicholas L., M.D., Medicine, Fatty Tissue. Junior Visiting Surgeon, Carney Hospital, Wollaston, Mass.

Slade, James V., Food Research. Business Manager, Central Laboratories, Hoboken, N.J.

Stern, Emanuel, M.D., Medical and Allied Sciences. Private Practice, New York, N.Y.

Stoddard, Leland D., M.D., Pathology. Associate Professor of Pathology, University of Kansas, Kansas City, Kansas.

Strauss, William Theodore, M.D., Medicine. Medical Advisor, Ciba Pharmaceutical Products Inc., Summit, N.J.

Tannenbaum, Myron, B.A., Endocrinology, Enzymology. Teaching Fellow, New York University, New York, N.Y.

Tuft, Harold S., M.D., Allergy. Assistant Professor, Medicine, Co-chief, Allergy Clinic, Hahnemann Medical College, Philadelphia, Pa.

Uram, Jerome A., M.S., Nutrition. Research Fellow, Department of Nutrition, Harvard School of Public Health, Boston, Mass.

Vandam, Leroy D., M.D., Anesthesiology. Assistant Professor, Hospital of the University of Pennsylvania, Philadelphia, Pa.

Van Rysselberghe, Pierre, Ph.D., Electrochemistry. Professor of Chemistry, University of Oregon, Eugene, Ore.

Villee, Claude A., Jr., Ph.D., Biological Chemistry. Assistant Professor of Biological Chemistry, Harvard Medical School, Boston, Mass.

Villeneuve, Paul, D.V.M., Physiology. Professor of Physiology, School of Veterinary Medicine, University of Montreal, Montreal, P. Q., Canada.

Volpitto, Perry P., M.D., Medicine, Anesthesiology. Professor, Medical College of Georgia, University Hospital, Augusta, Ga.

Von Bertalanffy, Ludwig, Ph.D., Theoretical and Quantitative Biology. Professor, University of Ottawa, Ottawa, Ont. Canada.

Von Bradish, Joseph A., Ph.D., Literature, Philosophy. Professor of Comparative Literature, School of Business and Civic Administration, The City College of New York, New York, N.Y.

Vonderbank, Hermann, Chemotherapy, Chemotherapeutisches Forschungsinstitut, Frankfurt, Germany.

Warfield, Robert B., Pharmaceutical Research. Supervisor, Pharmaceutical Laboratory, Bristol Myers Company, Hillside, N.J.

Watkins, David Hyder, M.D., Surgery. Associate Professor, University of Colorado, Denver, Colo.

White, Harold J., M.D., Pathology, Intern in Pathology, Yale University, New Haven, Conn.

Williams, Ned Blanchard, D.D.S., Medical Microbiology. Professor of Microbiology and Chairman of Department, School of Dentistry, University of Pennsylvania, Philadelphia, Pa.

Yang, Chia-Chih, Ph.D., Medical Physics. Associate, Medical Physics, University of Pennsylvania, Philadelphia, Pa.

Zeitlin, Benjamin R., M.D., Toxicology. Toxicologist, Central Laboratories, General Foods Corporation, Hoboken, N.J.

STUDENT MEMBERSHIP

Norden, Monroe L., B.S., Mathematical Statistics. Columbia University, New York, N.Y.